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IBM Systems Reference Library

Disk Storage Input/Output Instructions

This publication contains a description of the instructions used by the data processing system to operate the disk-storage units attached to it.

The instructions for the following disk-storage units are included in this publication:

IBM 1405 Disk Storage
IBM 1311 Disk Storage Drive
IBM 1301 Disk Storage

Timing information is also included on each disk-storage unit.

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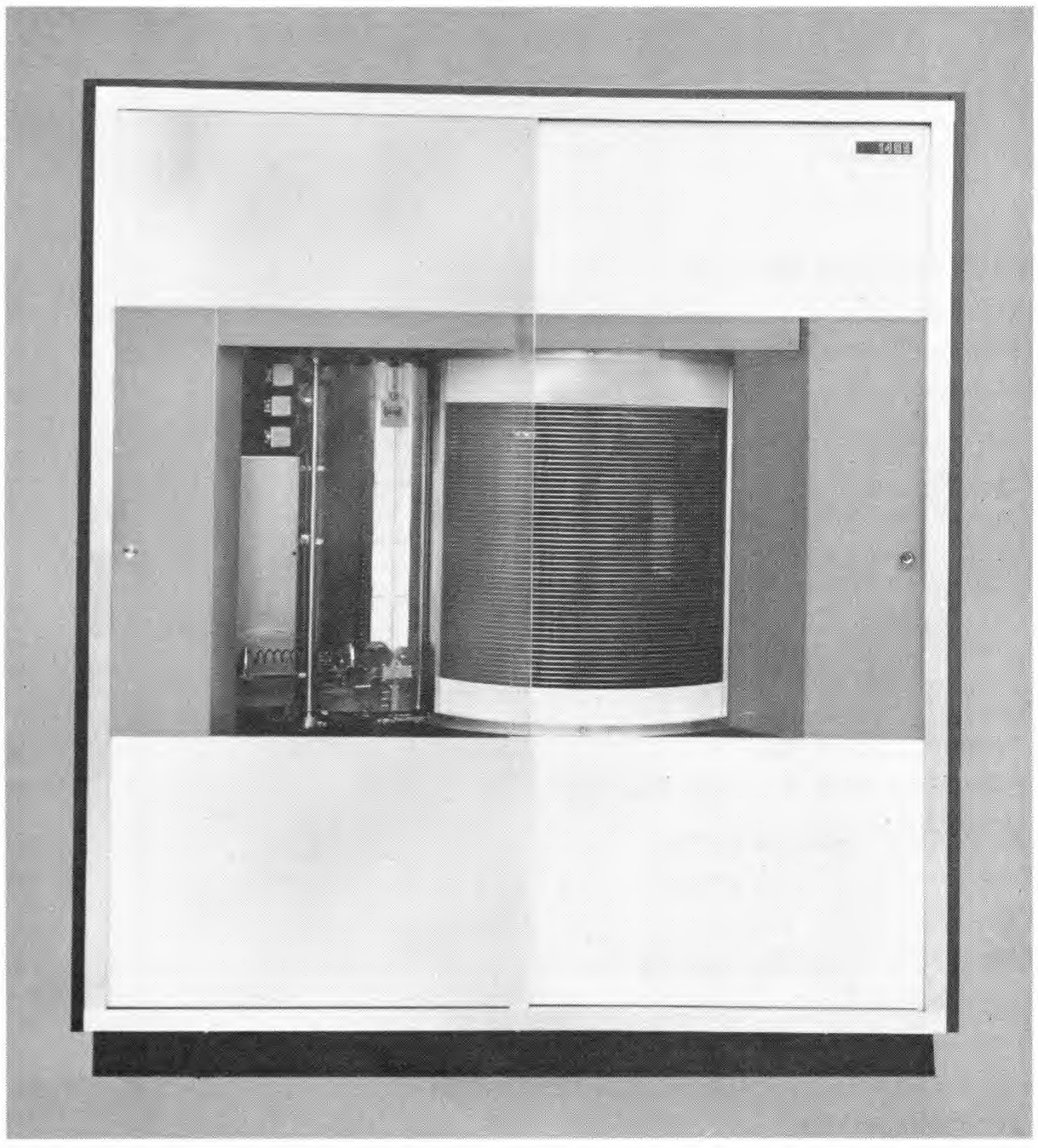


Figure 1. IBM 1405 Disk Storage

1405 Operation

The IBM 1405 Disk Storage unit (Figure 1) provides another medium of input/output for the IBM 1401. This unit is available in two models: Model 1, with a storage capacity of 10 million alphameric characters, and Model 2, with a storage capacity of 20 million characters.

Data Flow

The information is stored on the disks, which are divided into tracks and sectors so that the information can be located by the addressing scheme for reading and writing, during an input/output operation.

The disk-storage operation is directed by outside control from the stored program in the IBM 1401 Processing Unit.

1405 Instruction Format

Mnemonic	*Op. Code*	*A-address*	*B-address*	*d-character*
x	M or L	%Fx	xxx	R or W

Op Code

This is always a single character that defines the basic operation to be performed.

A-Address

%Fx always appears in the (A) portion of a 1401 disk-storage instruction. The %F signals that the disk unit is to be selected and the x represents the digit used to perform various operations:

X-Position	*Operation*
0	*Seek* a disk record.
1	*Single record*—Reading or writing of 200 characters is stopped when a group-mark with a word-mark, or the end of a sector, is sensed. If a group-mark with a word-mark is sensed before completing the reading of the sector of the track, reading stops and the wrong-length record indicator turns ON.
2	*Full track*—An entire track is read or written (5 sectors of 200 characters each. Reading or writing of the full track begins at the sector addressed and continues for four additional sectors. If a group-mark with word-mark is sensed before completing the reading of the last sector of the track, reading stops and wrong-length record indicator turns ON.
3	*Write check*—Data written on a disk in a preceding write operation is read from the disk and compared, character-by-character, with the data in core storage. A WRITE CHECK can be given following a single record or full-track operation.

B-Address

The B-address specifies the high-order position in core storage of the 8-digit record address. The record address must be followed by a group-mark with a word-mark and the area of core storage from which data is to be read into, or out of, by the disk-storage unit. The data area must be followed by a group-mark with a word-mark.

d-Character

The d-character is used to specify the operation to be performed.

1405 Instructions

Seek Disk

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU or LU *A* SD	M or L	%F0	xxx	R

Function. The A-address specifies that a seek operation is to be performed by the access arm. The B-address specifies the high-order position in core storage of the disk-record address, which is followed by a group-mark with a word-mark.

The selected access arm seeks the disk and track specified in the disk-record address. Processing can continue while the access arm is in motion.

Word Marks. Word marks are not affected.

Timing. $T = .0115 (L_I + 9)$ ms + access time.

Note: If the access arm is already at the disk track that is to be used, a SEEK DISK instruction need not be given.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 1	B + 8

Example. Seek record 050090 with access arm 1. Storage location 0590-0597 (labeled INPUTA) contain 10500900 (Figure 2).

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	(A) OPERAND ±	(A) OPERAND CHAR. ADJ.	(A) OPERAND RECORD MARK	(B) OPERAND ADDRESS	(B) OPERAND ±	(B) OPERAND CHAR. ADJ.	(B) OPERAND RECORD MARK	d
3 5	6 7	8 13	14 16	17	23		27	28	34		36	39
0 . 0			MU	%F0				INPUTA	-	7		R

Autocoder

Label	Operation	OPERAND
6 13	19 20	21 25 30 35 40 45 50
	SD	INPUTA-7

Assembled Instruction: M %F0 590 R

Figure 2. Seek Disk

Read Disk Single-Record
Read Disk Full-Track

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M	%Fx	xxx	R
A RD (single record)				
RDT (full track)				

Function. This instruction causes data to be read from disk storage into core storage. The digit 1 in the A-address (%F 1) specifies that a single record is to be read. The reading of the disk is stopped by a group-mark with a word-mark in core storage and the end of the sector. If the digit 2 is present in the A-address (%F 2), a full-track read occurs. That is, five 200-character records are read from disk storage into core storage. Reading stops at the end of the fifth sector.

The B-address specifies the high-order position in core storage of the disk-record address, which is followed by a group-mark with a word-mark, and the area in storage reserved for the data read from the disk.

The R in the d-character position signifies that this is a read operation.

Word Marks. A group-mark with a word-mark must appear one position to the right of the record address and one position to the right of the last position reserved in core storage for the disk record. If a group-mark with a word-mark is detected before reading of the record is completed, the wrong-length record indicator turns ON and reading stops.

Timing.

T = .0115 (L_I + 9) + 10 ms + disk rotation.

60.196 ms is maximum time for a single-record read.

10.196 ms is minimum time for a single-record read.

Note: Before reading starts, an automatic comparison of the record address in storage with the record address on the disk is made. If they are not the same, the unequal-address compare indicator turns ON, and the data on the disk cannot be read into storage.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 1	B + 210 or B + 1010

Example. Read a single record from disk storage to core storage, beginning at location 0599 (area is labeled INPUTA). The disk-record address is located in the first eight positions of the nine positions preceding the label (0590-0597), Figure 3.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	(A) OPERAND ±	(A) OPERAND CHAR. ADJ.	(A) OPERAND RECORD MARK	(B) OPERAND ADDRESS	(B) OPERAND ±	(B) OPERAND CHAR. ADJ.	(B) OPERAND RECORD MARK	d
3 5	6 7	8 13	14 16	17	23		27	28	34		36	39
0 . 0			MU	%F1				INPUTA	-	9		R

Autocoder

Label	Operation	OPERAND
6 13	19 20	21 25 30 35 40 45 50
	RD	INPUTA-9

Assembled Instruction: M %F1 590 R

Figure 3. Read Disk Single-Record (Full Track)

Read Disk Single-Record with Word Marks
Read Disk Full-Track with Word Marks

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS LU	L	%Fx	xxx	R
A RDW (single record)				
RDTW (full track)				

Function. These instructions are similar to the READ DISK SINGLE-RECORD and READ DISK FULL-TRACK instructions except that word marks in the record area of core storage are removed, and word marks from the disk records are written in core storage. The length of the record read into core storage from disk storage is 176 positions for a single record, and 880 positions for a full track.

Word Marks. A group-mark with a word-mark in core storage terminates the read operation. If the group-mark with a word-mark is not in the position to the right of the last character read from the disk into core storage, the wrong-length record indicator turns ON. A group-mark with a word-mark must be one position to the right of the record address.

Timing. T = .0115 (L_I + 9) ms + 10 ms + disk rotation.

Note: If a disk is read in a mode different from the one in which it was written (M or L operation code) a parity error occurs. The read-parity check indicator turns ON.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 1	B + 186 or B + 890

Example. Read a record from disk storage, with its associated word marks, into the area labeled INPUT (first position of data is at 0599). The disk-record address is located in the first eight positions of the nine positions preceding the label (0590-0597), Figure 4.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	(A) OPERAND ±	(A) OPERAND CHAR. ADJ.	(A) OPERAND REC MK	(B) OPERAND ADDRESS	(B) OPERAND ±	(B) OPERAND CHAR. ADJ.	(B) OPERAND REC MK	d
			L.U.	%F1				INPUT	-	9		R

Autocoder

Label	Operation	OPERAND
	RDW	INPUT-9

Assembled Instruction: L %F1 590 R

Figure 4. Read Disk Single-Record (Full Track) with Word Marks

Write Disk Single-Record
Write Disk Full-Track

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M	%Fx	xxx	W
A WD (single record)				
WDT (full track)				

Function. This instruction causes a single record (or full-track characters) in core storage to be written on a disk record. The digit 1 in the A-address (%F 1) specifies that a single record is to be written. If a 2 is present in the A-address (%F 2), five 200-character records are written on a disk track. Writing stops at the end of the fifth sector.

The B-address specifies the high-order position of the disk-record address and is followed by the data to be written on the disk.

The W in the d-character position signifies that this is a write operation.

Word Marks. The writing of data stops when the end of a record is reached on the disk and a group-mark with a word-mark is sensed in core storage. If the group-mark with a word-mark is sensed before the end of a record, the remainder of the disk record is filled with data from core storage and the wrong-length record indicator turns ON. A group-mark with a word-mark must be one position to the right of the record address.

Timing.

$T = .0115 (L_I + 9) + 10$ ms + rotation time.

60.196 ms is maximum time for single-record write.

10.196 ms is minimum time for a single-record write.

Note: Before writing starts, an automatic comparison of the record address in storage, with the record address on the disk, is made. If they are not the same the unequal-address compare indicator turns ON, and the data in storage cannot be written on the disk.

A WRITE DISK CHECK instruction must be performed following a write-disk operation. No other disk-storage operation can be performed until the check of data written on the disk is accomplished.

If the data in core storage contains characters with word marks, only the CBA 8421 portion of the character is written on the disk (the word mark is ignored).

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B+ 1	B + 210 or B + 1010

Example. Write a disk record (single) from the data in area labeled INPUTA (first position of data is at 0599). The disk-record address is located in the first eight positions of the nine positions preceding the label (0590-0597), Figure 5.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	(A) OPERAND ±	(A) OPERAND CHAR. ADJ.	(A) OPERAND REC MK	(B) OPERAND ADDRESS	(B) OPERAND ±	(B) OPERAND CHAR. ADJ.	(B) OPERAND REC MK	d
			MU	%F1				INPUTA	-	9		W

Autocoder

Label	Operation	OPERAND
	WD	INPUTA-9

Assembled Instruction: M %F1 590 W

Figure 5. Write Disk Single-Record (Full Track)

Write Disk Single-Record with Word Marks
Write Disk Full-Track with Word Marks

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS LU	L	%Fx	xxx	W
A WDW (single record)				
WDTW (full track)				

Function. This instruction is similar to the write disk operation, except that word marks present in the data in core storage are recorded on the disk record. The mode of operation permits the writing of programs on disk records for systems' use. One hundred and seventy-six positions of data with word marks are recorded on the disk during a write single-record operation, and 880 positions are recorded during a write full-track operation.

Word Marks. A group-mark with a word-mark one position to the right of the last character of the record in core storage terminates the write operation. If the group-mark with a word-mark is not in the correct position, the wrong-length record indicator turns ON. A group-mark with a word-mark must be one position to the right of the record address.

Timing. $T = .0115 (L_I + 9)$ ms + 10 ms + disk rotation.

Note: The programmer should be certain that all records on a specific track are written in the same mode (either by a MOVE or by a LOAD instruction), otherwise, full-track operations are not possible. A write-disk-check operation must be performed following this instruction.

Before writing starts, an automatic comparison of the record address in storage, with the record address on the disk, is made. If they are not the same, the unequal-address compare indicator turns ON, and the data in storage cannot be written on the disk.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 1	B + 186 or B + 890

Example. Write a disk record with word marks from the area labeled OUTPUT (the first position of data is 0599). The disk-record address is located in the first eight positions of the nine positions preceding the label (0590-0597), Figure 6.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
3 5	6 7	8 13	14 16	17 23			27	28	34		36	39
0 1 0			LU	%F1				OUTPUT-		9		W

Autocoder

Label	Operation	OPERAND
6 15	16 20	21 25 30 35 40 45 50
	MDW	OUTPUT-9

Assembled Instruction: L %F1 590 W

Figure 6. Write Disk Single-Record (Full Track) with Word Marks

Write Disk Check

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F3	xxx	W
LU (word marks)				
A WDC				
WDCW (word marks)				

Function. The function of this instruction is to cause a comparison, character-by-character, of the data in core storage with the data just written on the disk. The system automatically reads the disk record that was the last record to be addressed by the 1401 program. This instruction must follow a write operation.

The digit 3 in the A-address specifies that a WRITE DISK CHECK is to be performed. Either a single record or a full track is checked, depending on how the data was recorded in disk storage.

The B-address specifies the area in core storage where the record address and data recorded on the disk are located.

Word Marks. A group-mark with a word-mark must appear one position to the right of the disk-record address and of the disk data in core storage.

Timing. $T = .0115 (L_I + 9)$ ms + 50 ms.

Note: If the disk address in core storage is not the same as the address on the record, the unequal-address compare indicator turns ON. If any of the characters on the disk record do not agree with the characters in core storage, the read-back check-error indicator turns ON.

A WRITE DISK CHECK instruction can also follow a READ DISK SINGLE-RECORD instruction to verify data read from the disk.

The WRITE DISK CHECK and WRITE DISK CHECK WITH WORD MARKS instructions can have either an R or W specified as the d-character. A W d-modifier must be used for compatibility with the IBM 1410 Data Processing System.

If program compatibility with the IBM 1410 Data Processing System is necessary, the read check operation must be omitted.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 1	B + 210 or B + 1010

Example. Compare the disk record with the record in the area labeled OUTPUT (first position of data is 0699). The disk-record address is located in the first eight positions of the nine positions preceding the label (0690-0697), Figure 7.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
3 5	6 7	8 13	14 16	17 23			27	28	34		36	39
0 1 0			MU	%F3				OUTPUT-		9		W

Autocoder

Label	Operation	OPERAND
6 15	16 20	21 25 30 35 40 45 50
	MDC	OUTPUT-9

Assembled Instruction: M %F3 690 W

Figure 7. Write Disk Check

Branch if Indicator On

Instruction Format.

Mnemonic	*Op Code*	*I-address*	*d-character*
SPS B	B	xxx	x
A BIN			

Function. The d-character specifies the indicator tested. If the indicator is ON, the next instruction is taken from the I-address. If the indicator is OFF, the next sequential instruction is taken. Figure 8 shows symbols that are valid d-characters and the indicators they test.

The next disk-storage operation turns OFF the access-inoperable indicator. The other disk unit indicators are turned OFF by any disk operation except SEEK DISK.

d-CHARACTER	INDICATOR
N	Access Inoperable
V	Read- or Write Parity Check or Read-Back Check Error
W	Wrong-Length Record
X	Unequal-Address Compare
Y	Any Disk-Unit Error Condition

Figure 8. d-Character for BRANCH IF INDICATOR ON Instruction

Indicators: Access Inoperable—An access arm becomes inoperable if the logic safety circuit detects improper operation. A customer engineer can also render an arm inoperable. In either instance, this indicator turns ON when the program addresses the inoperable arm. At the same time, the appropriate access light (1405) and the RAMAC® light (1401) turn ON.

The indicator also turns on if an invalid (not installed) arm or disk storage unit is addressed. Because the program continues in sequence, even when an inoperable arm is addressed, a BRANCH IF INDICATOR ON instruction should follow a seek instruction.

Read or Write Parity-Check or Read-Back Check Error—This indicator turns ON if even-bit parity occurs when reading the record address and information from, or writing information on, a disk. Another condition that turns the indicator ON is an unequal compare during a write-check operation.

Wrong-Length Record—This indicator turns ON if the number of characters read from, or written on, the disk record is not equal to 200 or 1000 characters (for M operation code) or 176 or 880 characters (for L operation code).

Unequal-Address Compare—This indicator turns ON if an unequal condition occurs during the automatic comparison of the record address in storage with the record address on the disk. This is an automatic check and does not have to be programmed.

This is the same internal circuitry that is used by the COMPARE instruction. Care should be taken in programming that a normal-compare operation and the address-compare operation do not interfere with the setting of the equal, low, and high compare indicators set by a previous instruction.

Any-Disk-Unit Error Condition—This indicator turns ON if any of the other disk-storage indicators are ON. It can be tested by the program, and, if it is OFF, allows the program to proceed. If the indicator is ON, the other indicators should be checked to determine where corrective measures should be taken.

Word Marks. Word marks are not affected.

Timing.

Without indexing:

$T = .0115 (L_I + 1)$ ms

With indexing:

$T = .0115 (L_I + 2)$ ms.

Note: After each disk-unit read or write operation, the program must test for error indications to prevent processing of unusable data.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	BI	d*bb*

Example. At the completion of a disk-read operation, test the any-disk-unit error condition indicator. If it is OFF, continue in the main program. If it is ON, branch to the routine labeled DISKER (0690) to determine the type of error condition. This tests all disk-unit indicators and branches to the error routine of the respective indicator that is on. The routines are labeled: ACINOP (0690), UNADCL (0695), WRLENR (0700), RWPARC (0705), Figure 9.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	(A) OPERAND ±	(A) OPERAND CHAR. ADJ.	(A) OPERAND IND.	(B) OPERAND ADDRESS	(B) OPERAND ±	(B) OPERAND CHAR. ADJ.	(B) OPERAND IND.	d
3 5	6 7	8 13	14 16	17 23			27	28	34		36	39
0 1 0			B	DISKER								Y
0 2 0												
0 3 0												
0 4 0		DISKER	B	ACINOP								N
0 5 0			B	UNADCL								X
0 6 0			B	WRLENR								W
0 7 0			B	RWPARC								V
0 8 0												

Autocoder

Label	Operation	OPERAND
6 15	16 20	21 25 30 35 40 45 50
	B I N	DISKER,Y
DISKER	B I N	ACINOP,N
	B I N	UNADCL,X
	B I N	WRLENR,W
	B I N	RWPARC,V

Assembled Instruction:

480	B	690	Y
690	B	740	N
695	B	790	X
700	B	890	W
705	B	990	V

Figure 9. BRANCH IF INDICATOR ON Testing Routine

IBM 1405 Disk Storage Timing

Disk-Storage Access Time

To calculate timing for magnetic-disk operations, it is necessary to estimate the average time it takes to seek the records needed for a particular application. If input to the operation is in sequence, the average access time is less than if the input data is unsorted. This can be explained by the fact that the duration of the seek depends on how far the access arm must travel.

To seek a track on another disk, the access arm moves horizontally, vertically, and horizontally again. The minimum time to move from the outside track of one disk to the outside track of an adjacent disk is 415 milliseconds. The maximum length of a seek operation is from the inside track of the top disk to the inside track of the bottom disk and takes 800 milliseconds. Figure 10 shows track-to-track access times.

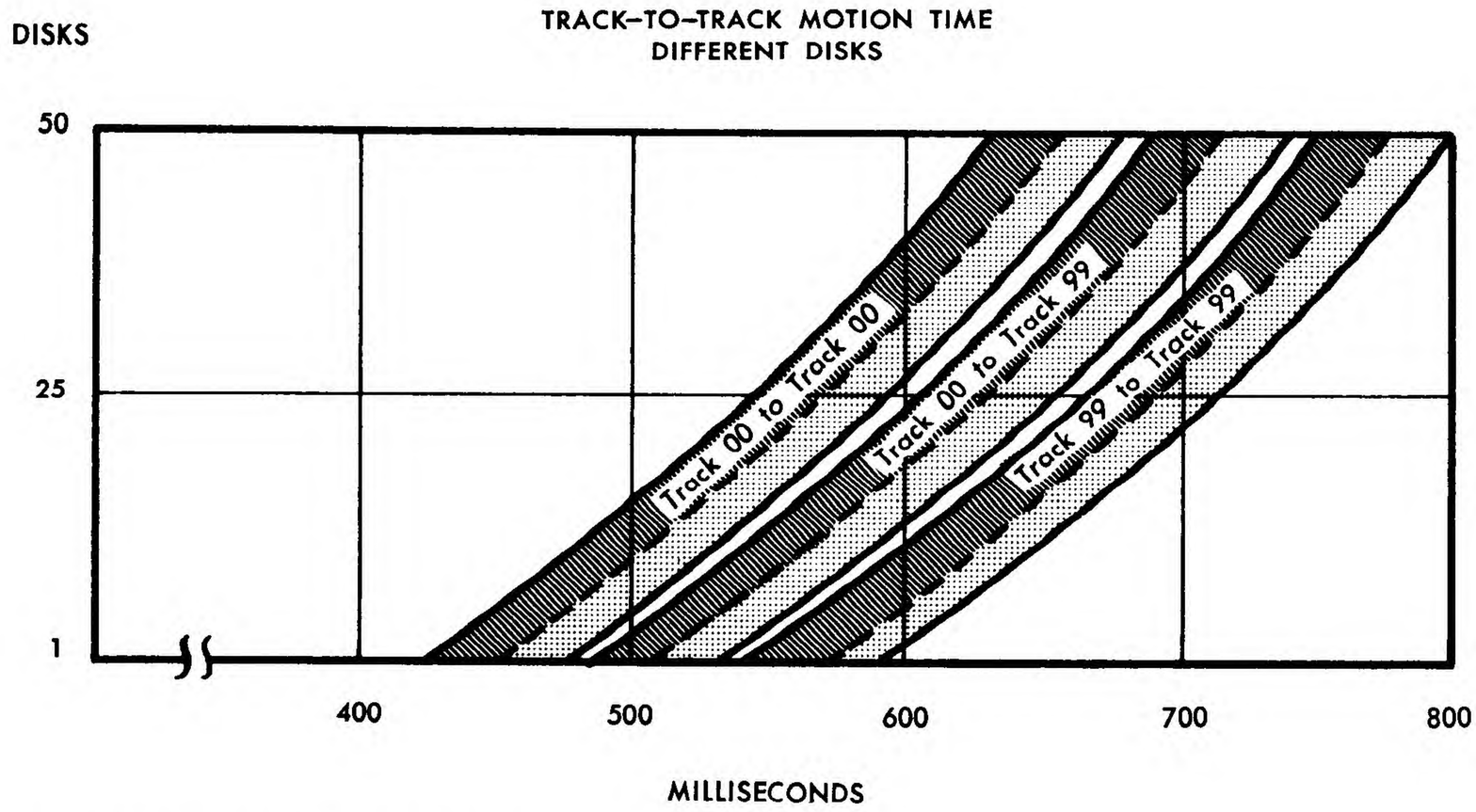


Figure 10. Track-to-Track Motion Time—Different Disks

To seek a different track on the same disk (top or bottom face), the arm moves horizontally only. In this case, minimum seek time is 90 milliseconds and maximum seek time is 250 milliseconds (Figure 11).

Disk-to-disk access time ranges from 100 to 315 milliseconds. Figure 12 shows timing for these operations.

IBM 1405 Error Routines

Figures 13 and 14 show the correct sequence of error tests and branches that should be made after disk-read and/or disk-write operations on the IBM 1405 Disk Storage unit. Failure to follow these sequences can result in undetected errors and/or end-around check conditions.

Disk-Read Error Routines

Figure 13 shows the correct sequence of error tests and branches that should be made after a disk-read operation. Explanation of the notes in Figure 13 follow.

Note 1

Access-inoperable (or invalid-address) is the only error indicator that can be set during a seek operation. Because disk errors do not stop the program operation,

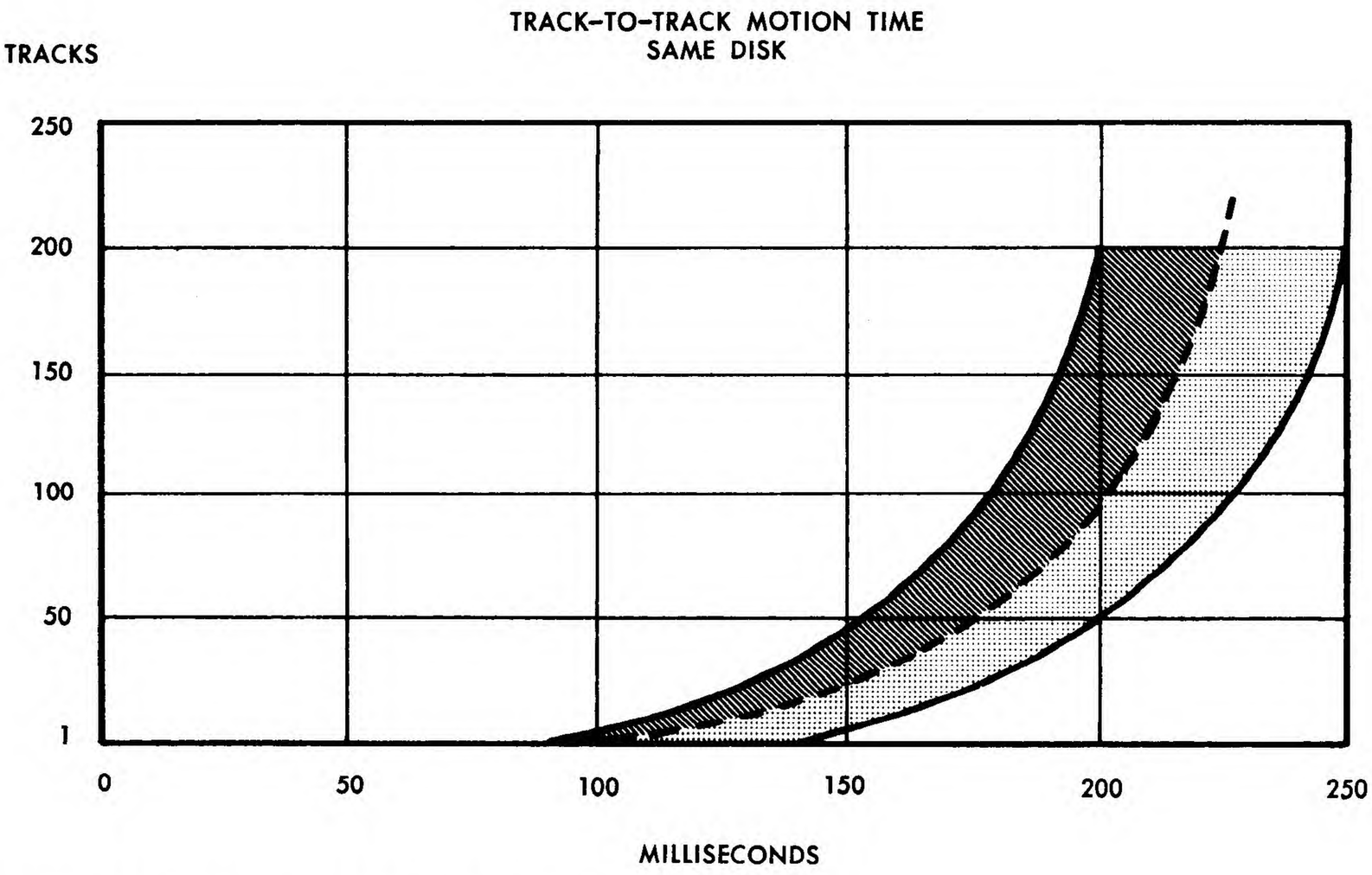


Figure 11. Track-to-Track Motion Time—Same Disks

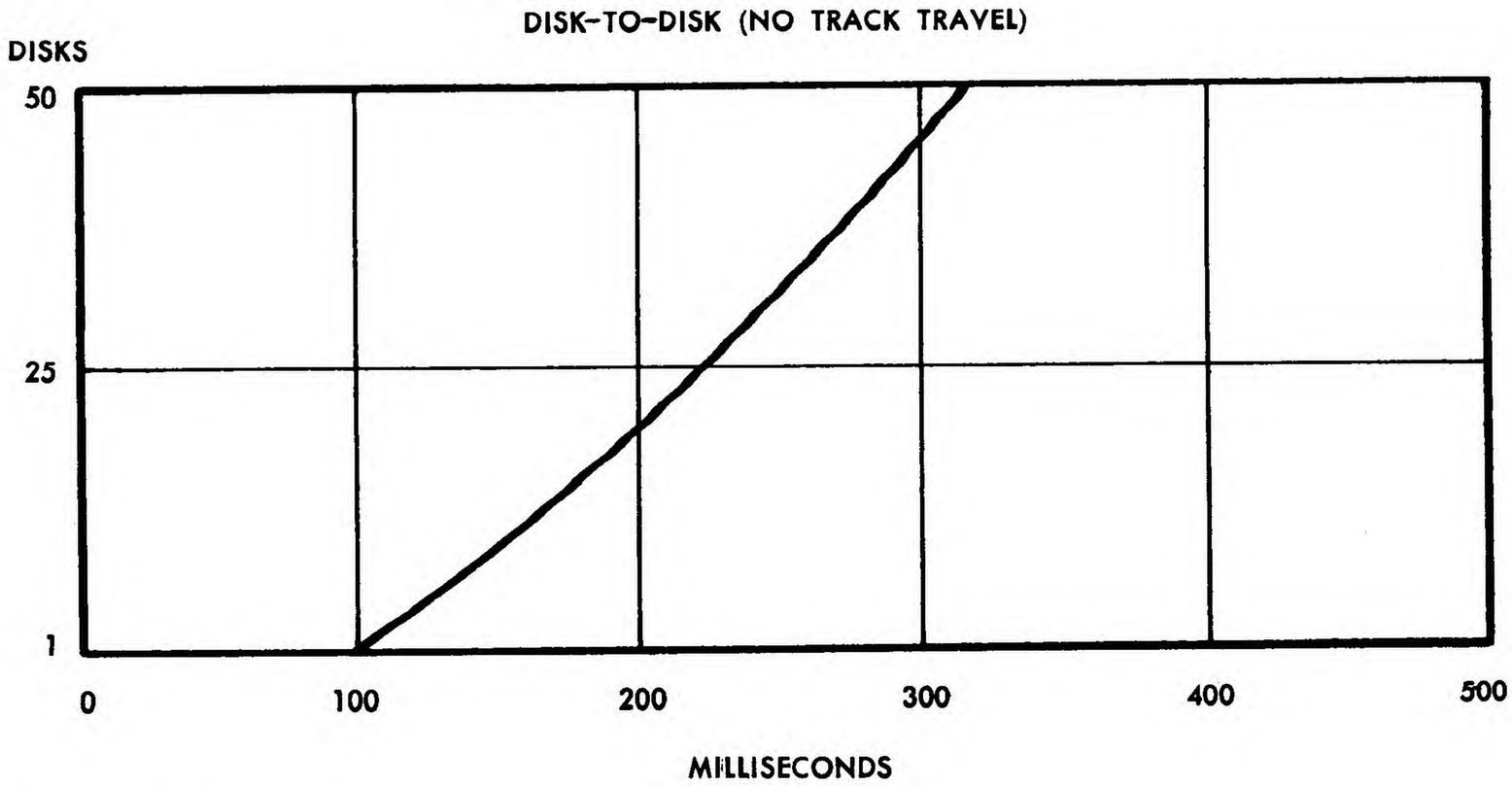


Figure 12. Disk-to-Disk Travel—(No Track Travel)

this indicator should be tested after a SEEK and, if ON, the operation should be retried.

Note 2

The access-inoperable (or invalid-address) and unequal-address compare indicators are set during the address phase of a disk-read operation. If either of these is ON, the operation ends and does not enter the record phase. The program should branch back to the SEEK DISK instruction. The parity and wrong-length record indicators are set during the record phase of a read operation. They should be tested and, if ON, the program should retry the read operation.

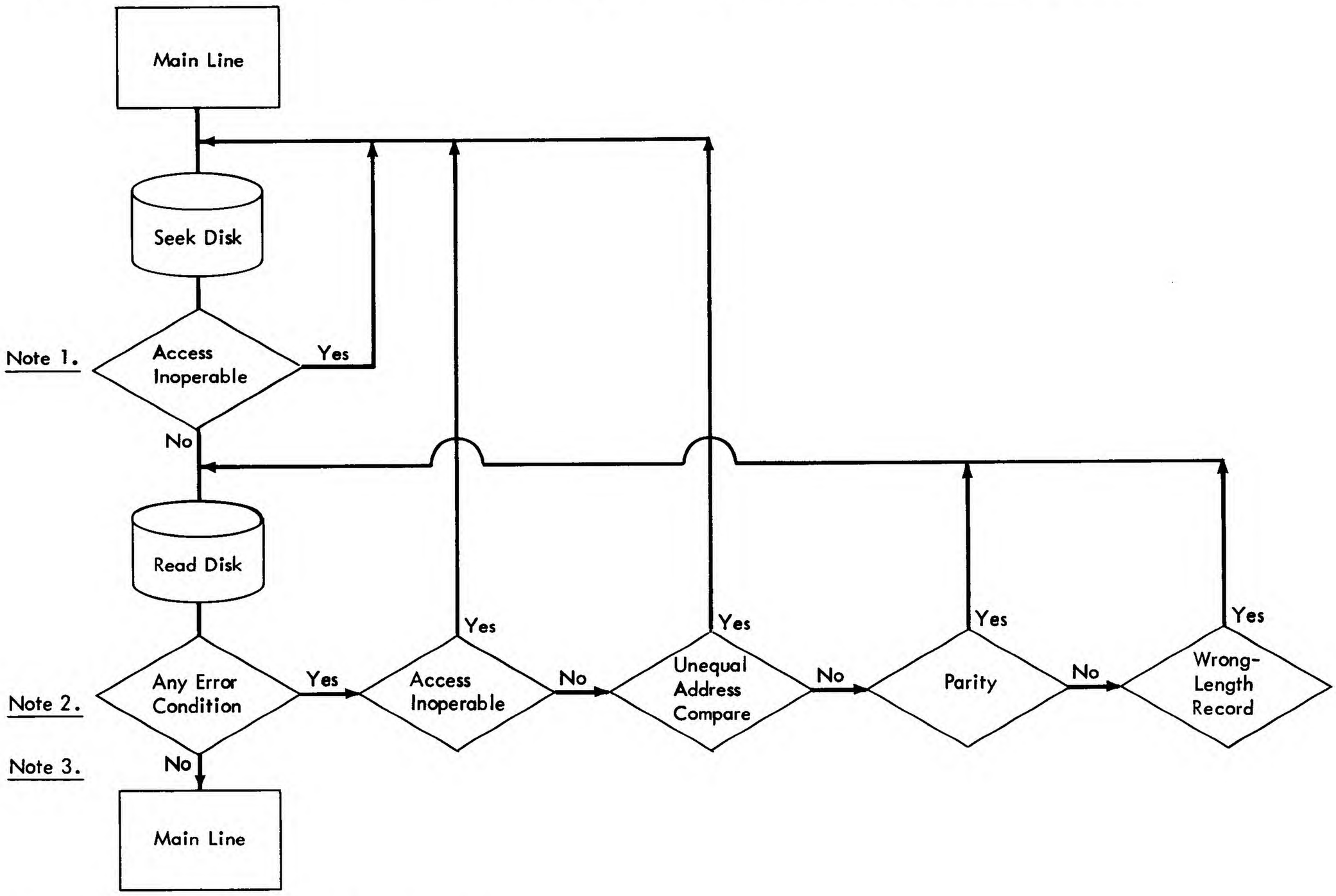


Figure 13. IBM 1405 Disk-Read Error Routine

Note 3

Disk-read operations are normally retried three times before halting.

Disk-Write Error Routine

Figure 14 shows the correct sequence of error tests and branches that should be made after a disk-write operation. Explanation of the notes in Figure 14 follow.

Note 1

Access-inoperable (or invalid-address) is the only error indicator that can be set during a seek operation. Because disk errors do not stop the program operation, this indicator should be tested after a SEEK and, if ON, the operation should be retried.

Note 2

The access-inoperable (or invalid-address) and unequal-address compare indicators are set during the address phase of a disk-write operation. If either of these errors occurs, the operation ends and does not enter the record phase. These indicators should be tested after a WRITE and, if ON, the program should branch back to the SEEK DISK instruction.

If neither the access-inoperable nor the unequal-address compare indicator is set ON, the operation enters

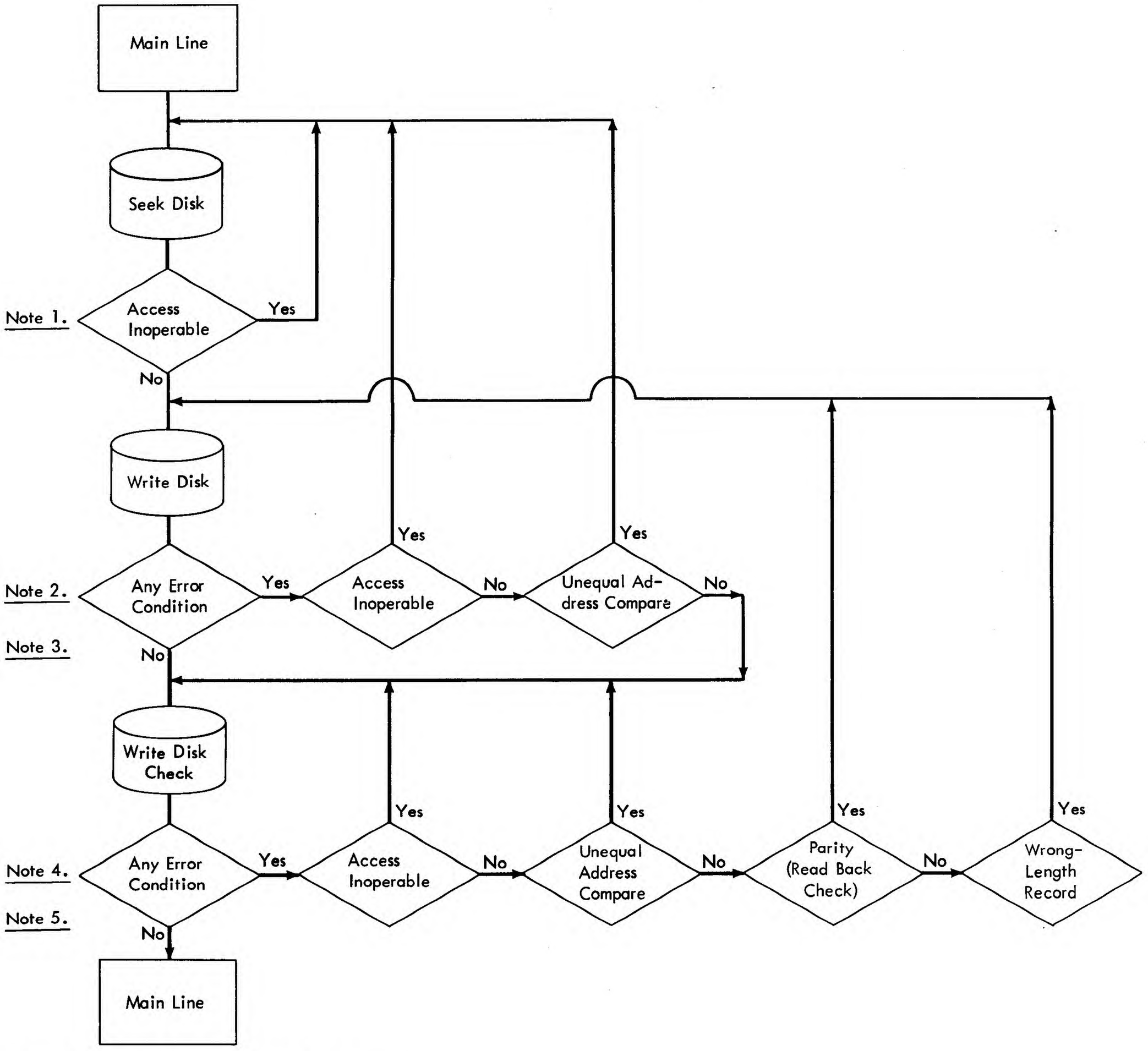


Figure 14. IBM 1405 Disk-Write Error Routine

the record phase and the write-check interlock is set. This requires that the next disk operation be a WRITE DISK CHECK. Although the parity and wrong-length record indicators can be set ON during a write operation, they are not tested before the WRITE DISK CHECK. If they were set ON by the WRITE, they will be set ON again by the WRITE DISK CHECK.

Note 3

Where possible, a processing loop is included between a WRITE and a WRITE DISK CHECK. If a programmed halt occurs in this loop and the start-reset key is pressed when restarting the program, all indicators are turned OFF. Therefore, the program should test the disk-error indicators before halting.

Note 4

If either the access inoperable or the unequal-address compare indicator is set ON during a write-disk-check operation, the operation ends and does not enter the record phase. The write-check interlock is still ON. This requires that the operation be retried.

Once the operation enters the record phase, the write-check interlock is turned OFF and, in the event of a parity (or read-back check) or wrong-length record error, the program should branch back to the write instruction.

Note 5

Disk-write operations are normally retried three times before halting.

IBM 1311 Disk Storage Drive

The IBM 1311 Disk Storage Drive (Figure 15) provides the 1401, 1440, and 1460 user with fast, efficient disk storage. As many as five IBM 1311 drives can be attached to a 1401, 1440, or 1460 system, and each drive is equipped with an interchangeable disk pack capable of storing from 2 to 2.9 million alphameric characters. The first disk-storage drive attached to the 1401 system must be a 1311, Model 4; additional drives are 1311, Model 2.

The first disk-storage drive attached to either the 1440 or 1460 system must be a 1311, Model 1; additional drives are 1311, Model 2.

Disk-Control Field

A 10-digit disk-control field specifies the disk-storage area that is involved in the data transfer. This disk-control field is located in core storage, and begins at the core-storage address specified by the disk-storage instruction B-address. The data involved in the transfer follows the disk-control field (no data area is required for a seek-disk operation).

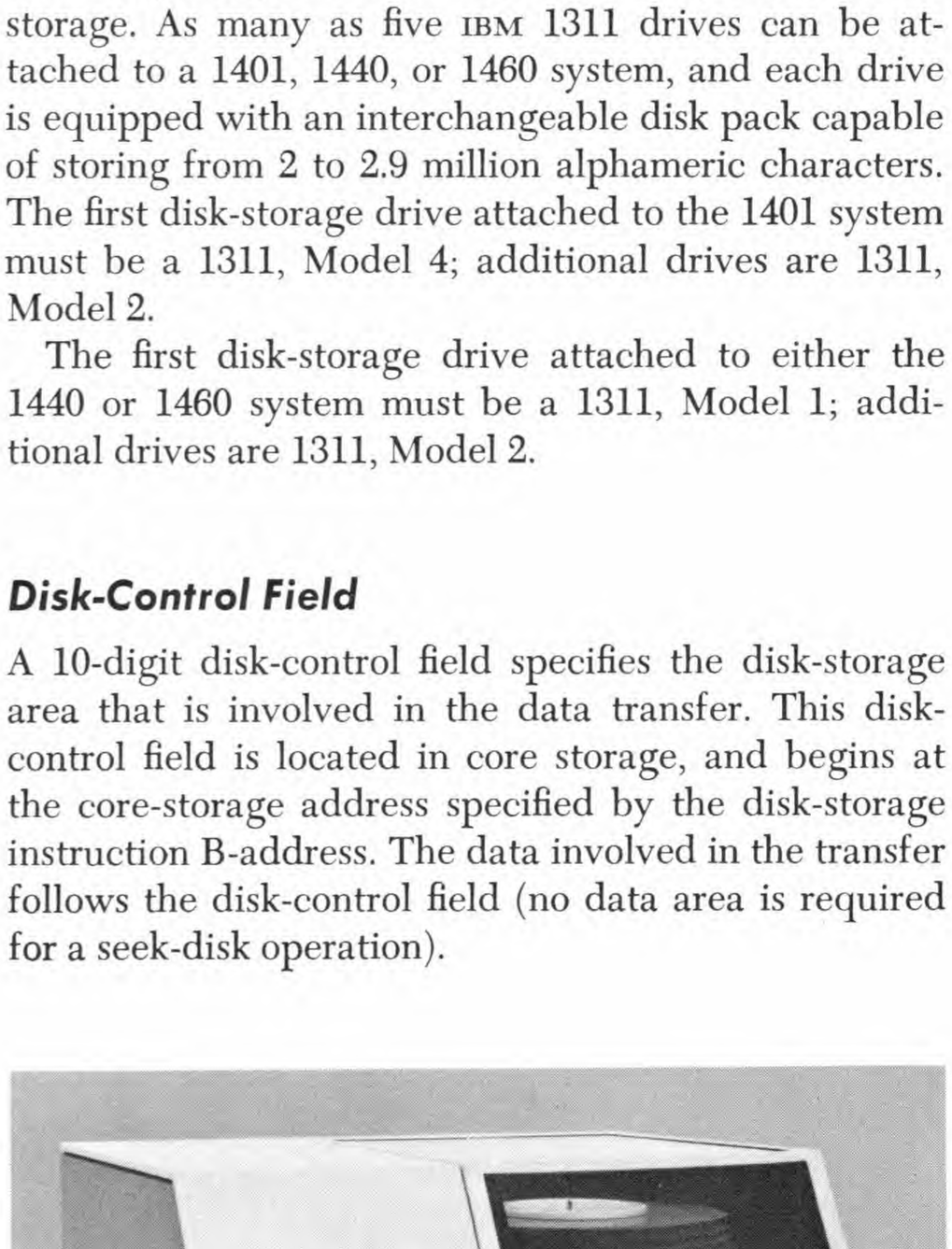


Figure 15. IBM 1311 Disk Storage Drive, Model 1

The various parts of the disk-control field are: alternate code, core sector address, and sector count (Figure 16).

Alternate Code	Core-Sector Address	Sector Count
x * or 0 - 8 (even)	xxxxxx 000000 - 099, 999	xxx 000 - 999

Figure 16. Disk-Control Field

Alternate Code

If an asterisk (*) is used in this position, the core sector addresses of the disk pack correspond to the address range for the disk drive on which the disk pack is placed.

A digit in the alternate-code position can be used to select the disk drive by the instruction. It allows drives with the same range of sector addresses to be used by the program during the same run.

When all disk drives have different sector addresses, an asterisk (*) instead of a numeric code can be placed in the alternate-code position if the address range of the disk packs and disk drive are the same.

Both word marks and zone bits can be placed in the alternate code position. The word marks and zone bits do not affect the operation and are not lost.

Core-Sector Address

The core-sector address contains the 6-digit address of the first sector to be operated upon. Before any disk operation is performed, an automatic comparison is made of the sector address in core storage with the disk-sector addresses on the specific track. If an equal comparison is made, the operation continues. If no equal comparison is made, the unequal-address compare indicator turns ON, and the disk operation is not performed.

When sector operations are performed, the core-sector address is automatically increased by 1 immediately following the data transfer of each sector, except under these conditions:

1. track operation being performed
2. sector-count field reaches the value of 000
3. wrong-length record.

When any of these conditions occur, the core sector address is not increased by 1.

Notes:

1. The high-order position of the 6-digit core sector address must contain a zero.
2. The other five positions of the 6-digit core sector address may contain any valid character that has a numeric-bit value of zero through nine.
3. Zone bits over the core sector-address positions are lost if any address modification takes place.
4. Word marks over the core sector address positions will not affect the operation, but are lost during any operation performed in the load mode that involves address modification.

Sector Count

This field indicates the number of sectors to be operated upon during the disk operation. The sector-count field is not used during seek operations. During the transfer of data to or from disk storage, the sector-count field is automatically decreased by 1 immediately following a successful address comparison so that the sector-count field reflects the number of successful address comparisons.

If a sector count of 000 is used when initiating a disk-sector read or write operation, an error condition occurs. Before the first sector is transferred, a 1 is subtracted from the sector-count field. In this case, the result would be 999. Therefore, data would be transferred until a group-mark with a word-mark is encountered in core storage. Because the sector count is not zero at this time, the wrong-length record and any-disk condition indicators would be turned ON.

Notes:

1. Word marks cannot be placed over the sector-count field units position. Word marks in any other position do not affect the operation, but are lost during any operation performed in the load mode that affects sector-count modification.
2. Zone bits are always removed from all three positions of the sector-count field.

Basic Disk Operations

The four basic operations performed by the 1311 are seek, read, write, and write disk check.

Seek Operation

The seek operation is initiated by a SEEK DISK instruction, which directs the read/write heads to the proper cylinder on the disk pack. This instruction is followed by a read or write operation.

The data on the disk records is not acted on during this seek operation.

The seek operation positions the access arms over the specified cylinder. The B-address position of the instruction contains the core-storage address of the disk-control field and it is this field that specifies the proper cylinder, plus other pertinent information.

Read Operation

The read operation is initiated by one of the three different types of READ DISK instructions, and transfers data from disk storage to a specified area in core storage. (The three types of instructions are discussed following the write-operation description.) The specified disk-storage area involved in the transfer is partially identified by the previous seek operation, and the rest of the area is fully identified before the data transfer takes place. The identification is accomplished by comparing the sector addresses on the disk with the sector address in core storage. The sector address in core storage is part of the disk-control field, and the B-address position of the READ DISK instruction contains the core-storage address of the disk-control field. The data from the disk is placed in a core-storage area located immediately to the right of the disk-control field.

Write Operation

The write operation is initiated by one of the three different types of WRITE DISK instructions, and transfers data from a specified core-storage area into disk storage. (The three types of instructions are discussed following this operation description.) The specific disk-storage area involved in the transfer is partially identified by the previous seek operation, and the rest of the area is fully identified before the data transfer takes place. The identification is accomplished by comparing the sector addresses on the disk with the sector address in core storage. The sector address in core storage is part of the disk-control field, and the B-address portion of the WRITE DISK instruction contains the core-storage address of the disk-control field. The data that will be transferred to the disk is stored in a core-storage area located immediately to the right of the disk-control field.

TYPES OF READ AND WRITE OPERATIONS

Each read or write operation can operate in three different ways, or modes: sector, track sectors with addresses, and sector-overlay modes.

Sector Mode. Read and write operations in the sector mode transfer data, but do not transfer disk sector addresses. The sector mode is the normal mode of operation. The number of sectors to be handled during one operation is specified by the sector-count portion of the disk-control field. Each sector is transferred only after a correct comparison of the sector address in the core-storage disk-control field is made with the sector address on the disk. For more detailed information, refer to the specific instruction.

Track Sectors with Addresses Mode. This mode of operation transfers both the data and the disk-sector addresses to and from the disk, one complete track

at a time. The mode of operation makes it possible to change the previously recorded sector addresses. The operation requires that the sector-address portion of the disk-control field contain the address of one of the sectors within the specified track, and the sector-count portion of the disk-control field must contain 020 (20 sectors will be transferred). The transfer can only occur after a correct comparison of the sector address in the core-storage disk-control field with a sector address on the specified track. For more detailed information, refer to the specific instruction.

Sector-Count Overlay Mode. This mode of operation allows a portion of the data record itself to specify the number of sectors that will be involved in the data transfer. The disk-sector addresses are not involved in the transfer. This mode of operation permits better disk storage utilization for sequential applications involving variable-size records. For more detailed information, refer to the specific instruction.

Reading and Writing with Word Marks. Word marks can be transferred with the data during all reading and writing operations by an L Op code instead of an M Op code. When word marks are written on the disk, the data is written in an 8-bit BCD coding.

Write Disk Check

The write-disk-check operation causes the data in the specified disk area to be compared against the comparable data in the specified core-storage area. When the disk data does not compare, bit-by-bit and character-by-character, with the core-storage data, a disk-error indicator is set ON. This operation normally takes the form of a WRITE DISK CHECK instruction, which must follow each write operation. The write-disk-check operation compares the data written in disk storage with the original source data in core storage.

1311 Instruction Format and Instructions

Mnemonic		*Op Code*	*A-address*	*B-address*	*d-character*
xx	*	M/L	%Fx	xxx	R/W

*Mnemonics for SPS shown with the instruction formats apply to the IBM 1401/1460 systems, and *Autocoder* mnemonics apply to the IBM 1401, 1440, and 1460.

Op Code

This is always a single character that defines the basic operation to be performed. Either the M or L operation code can be used with IBM 1311 instructions.

When the M Op-code is used, characters are written or read in 7-bit mode (CBA 8421). The L Op-code causes characters to be read or written in 8-bit mode (CBA 8421 M). The 8-bit mode provides for a possible word mark with the character being written on, or read from, the disk record.

A-Address

%Fx signals that the disk unit is to be selected; x represents the digit used to perform various operations.

X-Position	*Operation*
0	*Seek* a disk record.
1	*Sector*—Reading or writing characters from the number of sectors specified by the sector-count field is stopped when a group-mark with a word-mark, or the end-of-sector is sensed. If a group-mark with a word-mark is sensed before the reading of the sector(s) of the track is completed, reading stops and the wrong-length record and any-disk condition indicators turn ON. If the group-mark with a word-mark is sensed before the writing of a record on a disk is completed and it is before the end of a record, the remainder of the disk record is filled with valid blanks (C-bit), and the any-disk condition and wrong-length record indicators are turned ON.
6	*Disk Track-Sector with Addresses*—Allows the reading or writing of a full track (20 sectors) including sector addresses. To perform this operation, the write-address key-light on disk-storage unit 0 must be ON. When the write-address light is ON, write-sector operations cannot be performed.
3	*Write Disk-Check*—Data written on a disk in a preceding write operation is read from the disk and compared, character-by-character, with the data in core storage. A WRITE DISK CHECK must be given following a write operation, unless an error occurred *during* the write operation. A write-disk-check operation can be executed after a read operation if a check on the information read is desired. The operation is performed exactly the same as a write-disk-check operation following a write operation.
5	*Sector-Count Overlay*—Allows for records of a variable number of sectors (more than one) to be read or written with a single instruction. The number of sectors to be read/written is controlled by the multiple sector-count field. This control field is in the first three data positions of the first sector of the disk record. This technique permits better disk-storage utilization for sequential applications involving variable-size records. The record itself specifies the number of sectors involved.

B-Address

The B-address specifies the high-order position in core storage of the 10-digit disk-control field. The disk-control field is followed by the area of core storage that is to have data read into or out of by the disk-storage drive. The data area must be followed by a group-mark with a word-mark.

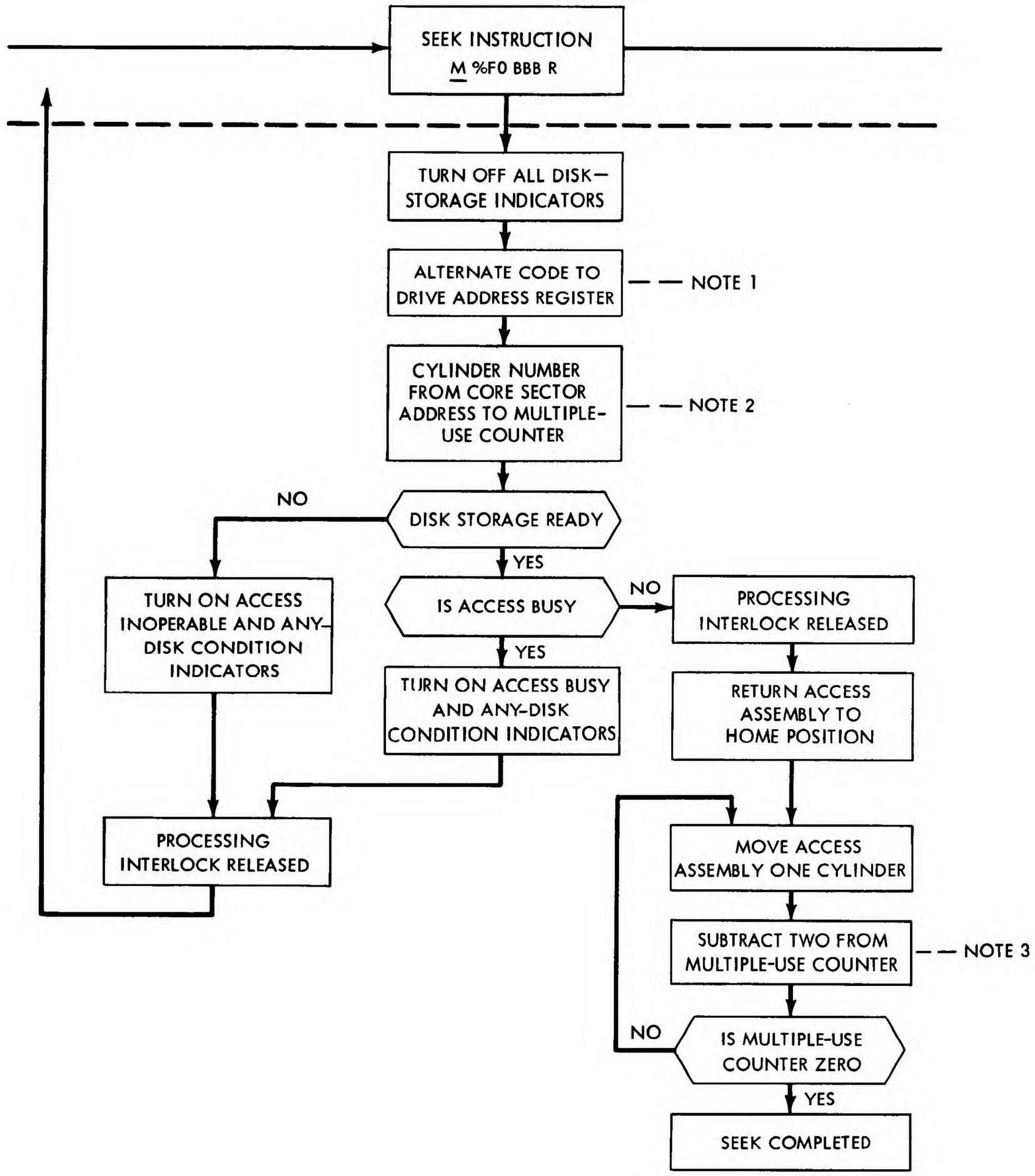
d-Character

The d-character is used to specify the operation to be performed.

Seek Disk

Instruction Format.

Mnemonic		*Op Code*	*A-address*	*B-address*	*d-character*
SPS	MU or LU	M or L	%F0	xxx	R
A	SD				



Note 1. Drive address is taken from 8, 4, 2,-bits of second address digit, if alternate code position has B-bit.

Note 2. Cylinder number is taken from:
a. 1-bit of second address digit
b. 8, 4, 2, 1-bits of third address digit
c. 8, 4, 2-bits of fourth address digit

Note 3. Subtraction does not take place when seeking to cylinder zero.

Figure 17. Seek-Disk Functional Schematic

Function. The A-address specifies that a seek operation is to be performed by the access assembly. The B-address specifies the high-order position in core storage of at least the first six functions of the disk-control field. Only the alternate-code position and the first five positions of the core-sector address are used during a seek-disk operation.

The selected access assembly is first withdrawn from the disks to the home position, and then is moved toward the center of the disk pack. Movement of the mechanism stops when the sought track is reached.

Refer to Figure 17 for a functional schematic of a seek-disk operation.

Word Marks. Word marks are not affected.

Timing. T = N* (L_I + 7) ms + access time.
400 ms is maximum access time for a seek.
250 ms is average access time for a seek.
0 ms if access mechanism is at track (SEEK DISK instruction not given).
*N = .0115 for 1401; .0111 for 1440; or .006 for 1460.

Note: If the access mechanism is already at the disk track that is to be used, a SEEK DISK instruction need not be given.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 7

Example. Seek record 015734 with the access assembly. Storage locations 0590-0599 (labeled INPUTA) contains 0015734001 (Figure 18).

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND	d
3 5	6 7	8 13	14 16	17 23			27	28 34			36	38
0 1 0			MU	%F0				INPUTA	-	9		R

Autocoder

Label	Operation	OPERAND
1 5	15 20	21 25 30 35 40 45 50
	SD	INPUT A-9

Assembled Instruction: M %F0 590 R

Figure 18. Seek Disk

Sector Operations

If only the data portion of a disk record is to be affected, the operation is classified as a *sector operation* (addresses are not affected). Disk records can be read, written, or scanned during sector operation. The term *sector operation* does not mean that a disk record is confined to a 100-character sector. The data needed for a record can be written in as many sectors as needed.

Read Disk Sector(s)

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU *A* RD	M	%F1	xxx	R

Function. This instruction causes data to be read from disk storage into core storage. The digit 1 in the A-address (%F1) specifies that a sector operation is to be performed. The number of sectors to be read is specified by the sector-count field. The reading of the disk is stopped by a group-mark with a word-mark in core storage and by the end of the sector.

Reading begins at the address contained in the core-sector address field and continues for the number of sectors specified by the sector-count field.

The core-sector address field is *increased* by one for each sector read, and the sector-count field is *reduced* by one as a sector is read.

When the sector-count field reaches 000, an end of operation is indicated to the system. An error condition results from any disk sector read or write operation that begins the operation with a sector count of 000. Before the first sector is transferred, a one (1) is subtracted from the sector-count field, resulting in a sector count of 999. Data would then be transferred until a group-mark with a word-mark is encountered in core storage. Because the sector count is not zero at this time, the wrong-length record and any-disk condition indicators are turned ON.

The B-address specifies the high-order position in core storage of the disk-control field, and the area in storage reserved for the data read from the disk.

The R in the d-character position signifies a read operation.

Refer to Figure 19 for a functional schematic of a read operation.

Word Marks. A group-mark with a word-mark must be one position to the right of the last position reserved in core storage for the disk record. If a group-mark with a word-mark is detected before reading of the record is completed, the wrong-length-record indicator turns ON and reading stops. The position of the group-mark with a word-mark can be determined by using the formula:

$$GM\text{-}WM = B + N_S(L_S) + 10$$

B = Address of high-order position of disk address in core storage

N_S = Number of sectors read

L_S = Number of characters per sector

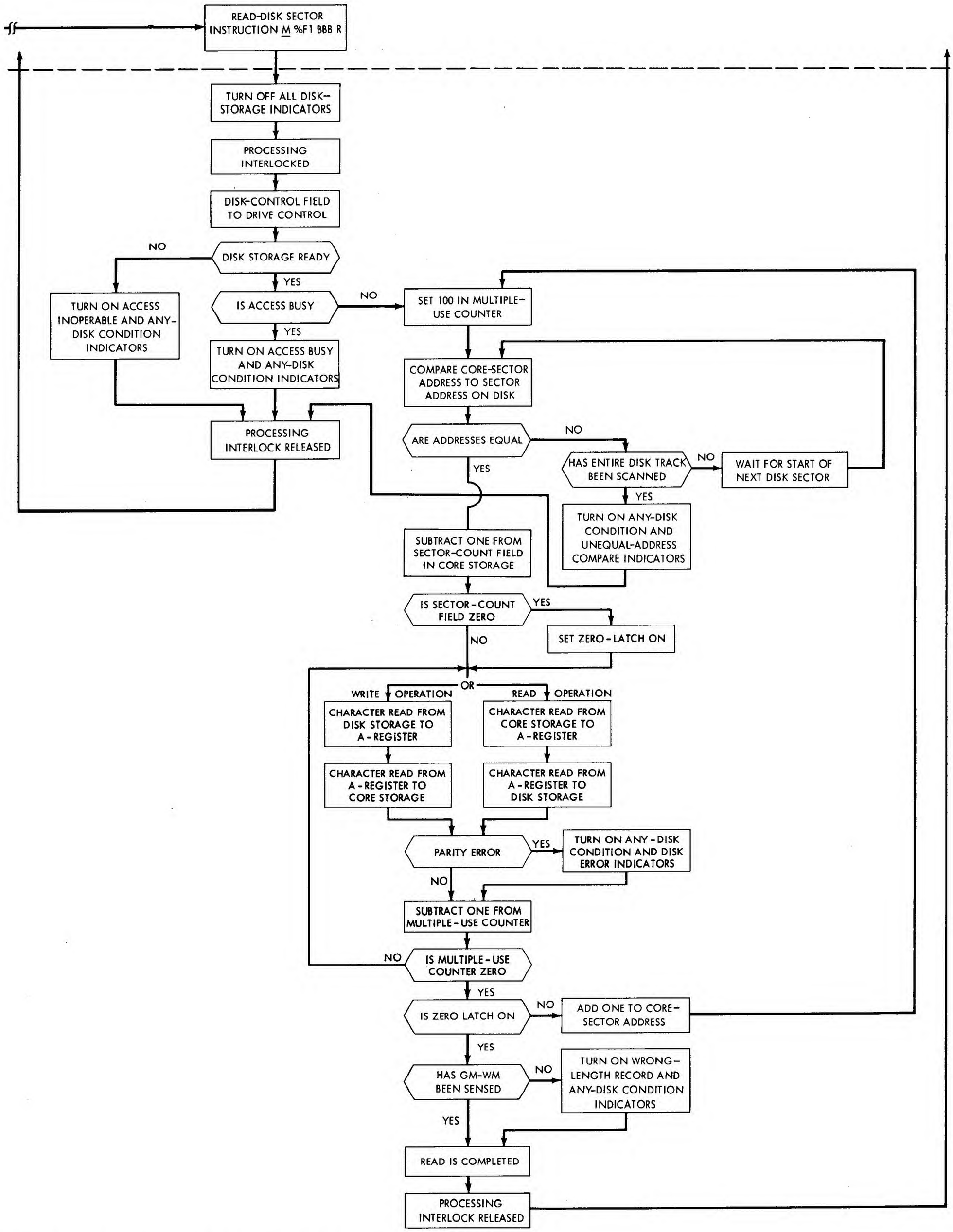


Figure 19. Read/Write Disk Functional Schematic

Timing. T = N (L_I + 1) ms + 2N_S + disk rotation.*

*42 ms is maximum time for disk rotation.
22 ms is average time for disk rotation.
2 ms is minimum time for disk rotation.

Note: Before reading starts, an automatic comparison is made of the core-sector address with the sector address on the disk. This check is made for each sector read. If they are not the same, the unequal-address compare indicator turns ON, and the data on the disk cannot be read into storage.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 11 + $N_S L_S$

Example. Read one sector from disk storage into core storage beginning at location 0600 (labeled INPUTA). The disk control field is located in the ten positions preceding the label (0590-0599), Figure 20.

SPS

LINE 3–5	COUNT 6–7	LABEL 8–13	OPERATION 14–16	(A) OPERAND ADDRESS 17–23	(A) OPERAND ±	(A) OPERAND CHAR. ADJ.	(A) OPERAND WM 27	(B) OPERAND ADDRESS 28–34	(B) OPERAND ±	(B) OPERAND CHAR. ADJ.	(B) OPERAND WM 36	d 39
0 1 0			MU	%F1				INPUTA	-	10		R

Autocoder

Label 6–15	Operation 16–20	OPERAND 21–80
	RD	INPUTA-10

Assembled Instruction: M %F1 590 R

Figure 20. Read Disk Sector

Read Disk Sector(s) with Word Marks

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS LU	L	%F1	xxx	R
A RDW				

Function. This is similar to the READ DISK SECTOR instruction except that (1) word marks in the record area of core storage are removed, and (2) word marks from the disk record are written in core storage. The length of the sector read from disk storage into core storage is 90 positions.

Word Marks. A group-mark with a word-mark in core storage terminates the read operation. If the group-mark with a word-mark is not in the position to the right of the last character read from the disk into core storage, the wrong-length-record and any-disk condition indicators turn ON.

Timing. T = N (L_I + 1) ms + 2N_S + disk rotation.*

*42 ms is maximum time for disk rotation.
22 ms is average time for disk rotation.
2 ms is minimum time for disk rotation.

Note: If a disk is read in a mode different from the one in which it was written (M or L operation code), a parity error occurs. The disk-error indicator turns ON.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 11 + $N_S L_S$

Example. Read a record, with its associated word marks, from disk storage into the area labeled INPUT (first position of data is at 0600). The disk control field is located in the ten positions preceding the label (0590-0599), Figure 21.

SPS

LINE 3–5	COUNT 6–7	LABEL 8–13	OPERATION 14–16	(A) OPERAND ADDRESS 17–23	(A) OPERAND ±	(A) OPERAND CHAR. ADJ.	(A) OPERAND WM 27	(B) OPERAND ADDRESS 28–34	(B) OPERAND ±	(B) OPERAND CHAR. ADJ.	(B) OPERAND WM 36	d 39
0 1 0			LU	%F1				INPUT	-	10		R

Autocoder

Label 6–15	Operation 16–20	OPERAND 21–80
	RDW	INPUT-10

Assembled Instruction: L %F1 590 R

Figure 21. Read Disk Sector with Word Marks

Read Disk with Sector-Count Overlay

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F5	xxx	R
LU (word marks)				
A RDCO				
RDCOW (word marks)				

Function. This operation is similar to the READ DISK SECTOR(s) instruction except that the number of sectors to be read is controlled by the first three positions in the first record read. The digit 5 in the A-address specifies that an overlay operation is to be performed.

As the first sector is read from disk storage, the first three digits of the record being read are placed in the sector-count field of the disk-control field in core storage. Therefore, if a variable number of sectors are to be read from disk storage, the sector-count field must contain a value greater than 001 to cause the first sector to be read. The first three positions of the first sector read contain the number of additional sectors to be read. Figure 22 illustrates the operation of an overlay instruction, which causes four sectors of data to be read from disk storage into core storage.

The operation proceeds as a normal read operation with appropriate changes to the core-sector address and sector-count fields.

Word Marks. Because the exact number of positions of data to be read from disk storage may not be known when this operation is initiated, place the group-mark with a word-mark (signaling the end-of-operation) one position to the right of the last possible character to be read using this instruction. If the

maximum number of records is not read, the read into storage stops because the end of sector is reached and the sector-count field is all zeros before the group-mark with a word-mark is sensed. The wrong-length-record indicator also turns ON. The programmer can check core storage in this case to see if the correct number of sectors have been read.

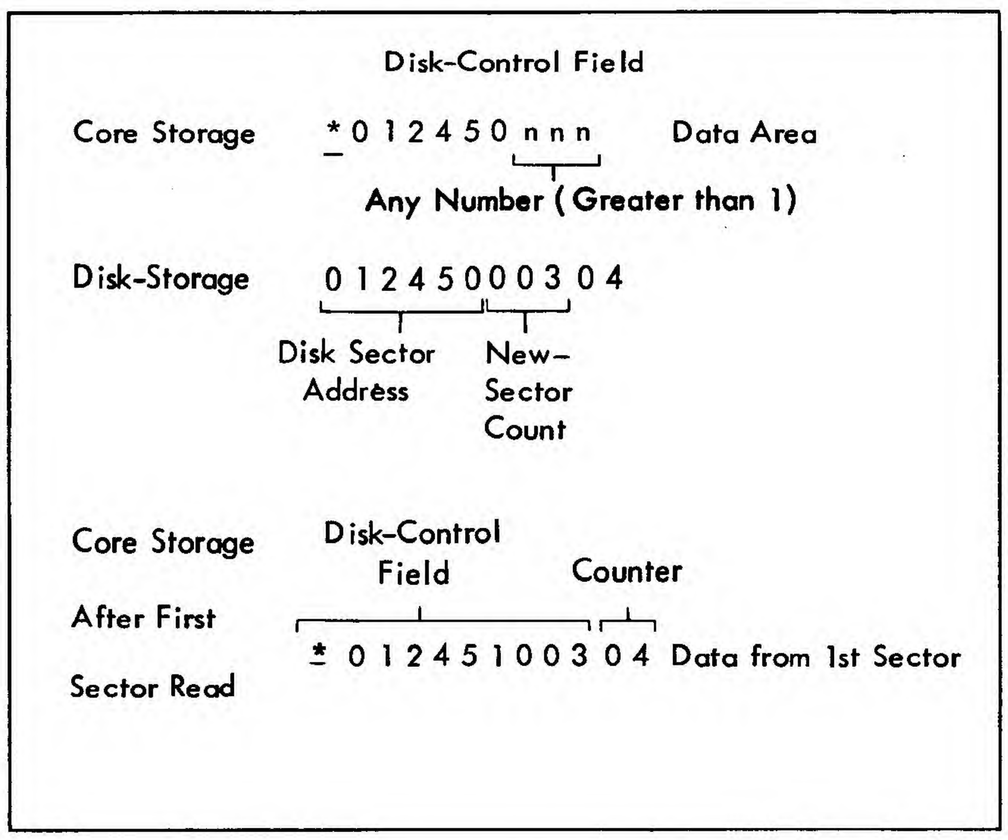


Figure 22. Read Disk—Sector-Count Overlay Operation

This can be accomplished by setting up a counter in the fourth and, if necessary, fifth position of the first sector of the record. This counter, when the read operation is completed, is located in the first and/or second position of the data record in core storage. These positions can be used to check the number of sectors in the record. These counter positions should equal the actual number of sectors in the record. For any record length other than single-sector records, reading data from disk should have stopped at $B + 6 + N_S L_S$. If it did not, then an error did occur and appropriate action should be taken. If a correct read has occurred, the error indication can be disregarded.

Special consideration must be given to single-sector records when read in the Sector-Count Overlay mode. When the read operation begins, the first three characters of the record overlay the sector count. In this case, 000 is read in and overlaid. However, the machine does not detect a zero sector count except when produced by automatically decreasing the sector-count field. After reading the single-sector record, the address is increased by one and an equal compare is sought on the next sector. When found, the sector count field is decreased by one again, resulting in a count of 999. The read will continue until the group-mark with a word-mark is sensed. Because the sector count field is not all zeros when this occurs, the wrong-length-record indicator is turned ON.

When a file includes single-sector records, a special routine must be included to verify the validity of the record read. Before executing a read, a special character that would never be found in the last position of a record can be moved to the 100th position of the input area. The wrong-length-record routine can then check to see whether the counter in the first position of the record contains a one (1). If so, it would check to see that the special character has been overlaid. If it has, the record was read in its entirety.

Timing. $T = N (L_I + 1)$ ms $+ 2N_S +$ disk rotation.*
*42 ms is maximum time for disk rotation.
22 ms is average time for disk rotation.
2 ms is minimum time for disk rotation.

Note: Before reading starts, an automatic comparison is made of the record address in core storage with the record address on the disk. This check is made as each sector is read. If the addresses are not the same, the unequal-address compare indicator is turned ON, and the data on the disk cannot be read into storage.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	$B + 8 + N_S L_S$

Example. Read into core storage a variable number of sectors that contain the data for a record beginning at location 0900 (labeled INPUTB). The disk control field is located in the ten positions preceding the label (0890-0899), Figure 23.

SPS

LINE (3–5)	COUNT (6–7)	LABEL (8–13)	OPERATION (14–16)	(A) OPERAND ADDRESS (17)	± (23)	CHAR. ADJ. (24–27)	(B) OPERAND ADDRESS (28)	± (34)	CHAR. ADJ. (35–38)	d (39)
0 1 0			MU	%F5			INPUTB	–	10	R

Autocoder

Label (6–15)	Operation (16–20)	OPERAND (21–50)
	RDCO	INPUTB-10

Assembled Instruction: M %F5 890 R

Figure 23. Read Disk with Sector-Count Overlay

Write Disk Sector(s)

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU *A* WD	M	%F1	xxx	W

Function. This instruction causes record data in core storage to be written on a disk record. The digit 1 in the A-address (%F1) specifies that a sector operation is to be performed. The number of sectors to be

written is specified by the sector-count field. The writing of the disk record is stopped by a group-mark with a word-mark in core storage and by the end of sector.

Writing begins at the address contained in the core-sector address field and continues for the number of sectors specified by the sector-count field.

The core-sector address field is *increased* by one for every sector written. The sector-count field is *reduced* by one as a sector is written.

When the sector-count field reaches 000, an end-of-operation is indicated to the system. An error condition results from any disk sector read or write operation that begins the operation with a sector count of 000. Before the first sector is transferred, a one (1) is subtracted from the sector-count field, resulting in a sector count of 999. Data would then be transferred until a group-mark with a word-mark is encountered in core storage. Because the sector count is not zero at this time, the wrong-length record and any-disk condition indicators are turned ON.

The B-address specifies the high-order position in core storage of the disk-control field, and is followed by the data to be written on the disk.

The W in the d-character position signifies a write operation.

Refer to Figure 19 for a functional schematic of a write operation.

Word Marks. A group-mark with a word-mark must be *one* position to the right of the last character of the record in core storage. The writing of data stops when the end-of-record is reached on the disk and a group-mark with a word-mark is sensed in core storage. If the group-mark with a word-mark is sensed before the end of a record, the remainder of the disk record is filled with valid blanks (C-bit), and the any-disk condition and wrong-length-record indicators are turned ON.

Timing. $T = N (L_I + 1)$ ms $+ 2N_S +$ disk rotation.*

*42 ms is maximum time for disk rotation.
22 ms is average time for disk rotation.
2 ms is minimum time for disk rotation.

Notes: Before writing starts, an automatic comparison is made of the core-sector address with the record address on the disk. This check is made for each sector written. If the addresses are not the same, the unequal-address compare indicator is turned ON, and the data in storage cannot be written on the disk.

If the data in core storage contains characters with word marks, only the CBA8421 portion of the character is written on the disk (the word mark is ignored).

A WRITE DISK CHECK instruction must be performed following a write disk operation unless an error occurred during the write operation. No other disk-storage operation can be performed until the check of data written on the disk is accomplished.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 11 + N_SL_S

Example. Write a disk record (one sector) from the data in the area labeled INPUTA (first position of data is at 0600). The disk-control field is located in the ten positions preceding the label (0590-0599), Figure 24.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
3 5	6 7	8 13	14 16	17	23		27	28	34		36	39
0 0			MU	%F1				INPUTA-		10		W

Autocoder

Label	Operation	OPERAND
6 15	16 20	21 25 30 35 40 45 50
	WD	INPUTA-10

Assembled Instruction: M %F1 590 W

Figure 24. Write Disk Sector

Write Disk Sector(s) with Word Marks

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS LU A WDW	L	%F1	xxx	W

Function. This instruction is similar to the WRITE DISK SECTOR instruction, except that word marks set with the data in core storage are recorded on the disk record. This mode of operation permits writing programs on disk records for system use. Ninety positions of data with word marks are recorded on each sector during the write operation.

Word Marks. A group-mark with a word-mark one position to the right of the last character of the record in core storage terminates the write operation. If the group-mark with a word-mark is not sensed at the same time as the end of a record, the remainder of the disk record is filled with valid blanks (C-bit), and the any-disk condition and the wrong-length-record indicators are turned ON.

Timing. $T = N (L_I + 1)$ ms $+ 2N_S +$ disk rotation.*

*42 ms is maximum time for disk rotation.
22 ms is average time for disk rotation.
2 ms is minimum time for disk rotation.

Notes: The programmer should be certain that all records on a specific track are written in the same mode (M or L operation code). Otherwise, track operations are not possible.

Before writing starts, an automatic comparison is made of the record address in storage with the record address on the disk. If the addresses are not the same, the unequal-address compare indicator is turned ON, and the data in storage cannot be written on the disk. A write-disk-check operation must be performed following this instruction.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 11 + N_SL_S

Example. Write a disk record, with word marks, from the data in the area labeled OUTPUT (first position of data is 0600). The disk-control field is located in the ten positions preceding the label (0590-0599), Figure 25.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
0 1 0			LU	%F1				OUTPUT	-	10		W

Autocoder

Label	Operation	OPERAND
	WDW	OUTPUT-10

Assembled Instruction: L %F1 590 W

Figure 25. Write Disk Sector with Word Marks

Write Disk with Sector-Count Overlay

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F5	xxx	W
LU (word marks)				
A WDCO				
WDCOW (word marks)				

Function. This operation is similar to the WRITE DISK SECTOR instruction except that the sector-count field of the disk-control field is automatically decreased by one and then written in the first three data positions of the first sector written. The digit 5 in the A-address specifies that an overlay operation is to be performed.

Therefore, if a variable number of sectors are to be written on disk storage, the sector-count field in core storage should contain the number of sectors to be written. The first three data positions of the first sector written contain the number of additional sectors that were written. Figure 26 illustrates the operation of an overlay instruction, which causes four sectors of data to be written from core storage onto disk storage.

The operation proceeds as a normal write operation with appropriate changes to the core-sector address and sector-count fields.

Word Marks. A group-mark with a word-mark should be placed one position to the right of the last sector to be written. The group-mark with a word-mark must be placed at B + 7 + N_SL_S to avoid a false wrong-length-record indication.

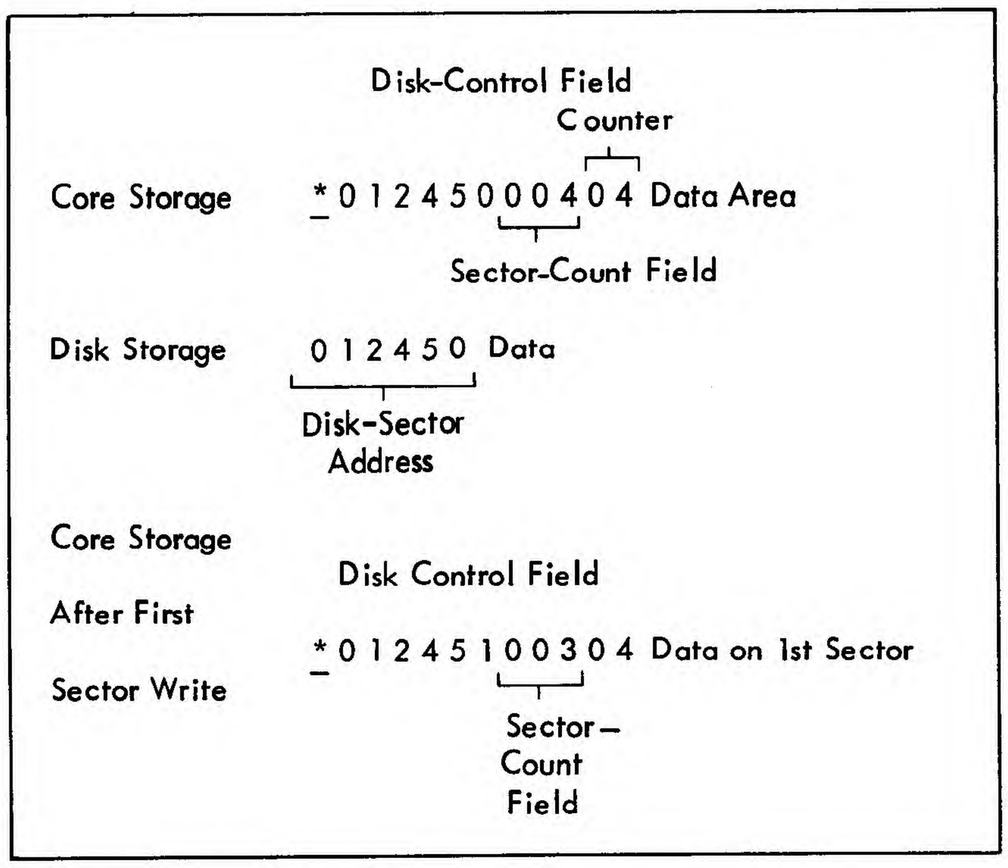


Figure 26. Write Disk—Sector-Count Overlay Operation

Timing. T = N (L_I + 1) ms + 2N_S + disk rotation.*

*42 ms is maximum time for disk rotation.
22 ms is average time for disk rotation.
2 ms is minimum time for disk rotation.

Note: Before writing starts, an automatic comparison is made of the record address in core storage with the record address on the disk. This check is made before each sector is written. If the addresses are not the same, the unequal-address compare indicator is turned ON, and the data in core storage cannot be written in disk storage.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 8 + N_SL_S

Example. Write a number of sectors for a record on disk storage that contains data beginning at location 0900 (labeled OUTPUT). The disk control field is located in the ten positions preceding the label (0890-0899), Figure 27.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
0 1 0			MU	%F5				OUTPUT	-	10		W

Autocoder

Label	Operation	OPERAND
	WDCO	OUTPUT-10

Assembled Instruction: M %F5 890 W

Figure 27. Write Disk with Sector-Count Overlay

Write Disk Check

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F3	xxx	W
LU (word marks)				
A WDC				
WDCW (word marks)				

Function. This instruction causes a comparison, character-by-character, of the data in core storage with the data just written on the disk. This instruction must be executed after a write operation and before any other disk-storage operation is initiated.

The digit 3 in the A-address specifies that a WRITE DISK CHECK is to be performed. Either an L or M operation code is used, depending on how the data was recorded in disk storage.

The B-address specifies the area in core storage that contains the disk-control field and the data recorded on the disk.

The sector-address and sector-count fields of the sector-control word must be restored to the values present at the beginning of the write operation.

Word Marks. A group-mark with a word-mark must appear one position to the right of the disk data in core storage.

Timing. $T = N (L_I + 1)$ ms $+ 2N_S +$ rotation time.*

*42 ms is maximum time for disk rotation.
22 ms is average time for disk rotation.
2 ms is minimum time for disk rotation.

Notes: If the disk address in core storage is not the same as the address on the record, the unequal-address compare indicator turns ON. If any of the characters on the disk record do not agree with the characters in core storage, the disk-error indicator turns ON.

A write-disk-check operation can be executed after a read operation if a check on the information read is desired. The operation is performed exactly the same as a write-disk-check operation following a write operation.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	Depends on previous operation	

Example. Compare the disk record with a record in core-storage area labeled OUTPTC (beginning at 0700). This disk-control field is located in the ten positions preceding the label (0690-0699), Figure 28.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	d
			MU	%F3			OUTPTC-1		0	W

Autocoder

Label	Operation	OPERAND
	WDC	OUTPTC-10

Assembled Instruction: M %F3 690 W

Figure 28. Write Disk Check

Address Operations

The disk sector addresses written on the disk pack are protected from improper systems operation by the write-address key-light on disk-drive 0. When the light is OFF, addresses on the disk pack cannot be altered or read into core storage. If the light is ON, disk-pack addresses can be read into core storage and new addresses can be written on the disk pack.

The ability to read and/or alter disk addresses is conditioned by the setting of the write-address key-light and the stored program instructions. Certain IBM 1311 instructions are used when reading or writing disk addresses. These instructions contain the term *Address* in their description and a note on the setting of the write-address key.

If the proper instruction and key setting are not used when trying to perform an address operation, the system stops and the RAMAC light on the system console turns ON.

Read Disk Track Sectors with Addresses

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F6	xxx	R
LU (word marks)				
A RDT				
RDTW (word marks)				

Function. This instruction causes the contents of an entire disk track (addresses and data) to be read in the mode specified by the operation code (M or L). If the L operation code is used, the track is read into storage with its associated word marks.

The core-sector address must correspond to any one of the sector addresses on the track. The disk track is scanned for an address equal to the sector address in core storage. The disk-track reading begins when the first track-index pulse following a successful address-compare operation is sensed. If the result of the address-compare operation is unequal, the unequal-address compare indicator turns ON. All twenty sectors on the track, including the disk-sector addresses, are read into core storage. The sector-count field of the disk address must be set at 020 before the operation begins.

The core-sector address field is not modified by plus-one during this operation. To keep track of the number of sectors read, however, the sector-count field is modified by minus-one for each sector read.

Word Marks. A group-mark with a word-mark must be placed one position to the right of the last character read into core storage. This position can be found by adding 2130 to the B-address for operations performed with the M operation code, and 1930 for operations performed with the L operation code.

Timing. $T = [N (L_I + 1) + 42]$ ms + disk rotation.*

*42 ms is maximum time for disk rotation.
22 ms is average time for disk rotation.
2 ms is minimum time for disk rotation.

Note: The write-address key-light on disk-storage-drive zero must be ON to perform the operation. When the key-light is OFF, disk-sector operations cannot be performed.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 9	B + 11 + 2120 (M Op code) or B + 11 + 1920 (L Op code)

Example. Read disk track 17550, with its associated word marks, into the core-storage area labeled RDTSAD (first position of data is at 0800). The disk control field is located in the ten positions preceding the label (0790-0799), Figure 29.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
3 5	6 7	8 13	14 16	17	23		27	28	34		36	39
0 1 0			MU	%F6				RDTSAD	-	10		R

Autocoder

Label	Operation	OPERAND
6 15	16 20	21 25 30 35 40 45 50
	RDT	RDTSAD-10

Assembled Instruction: M %F6 790 R

Figure 29. Read Disk Track Sectors with Addresses

Write Disk Track Sectors with Addresses

Instruction Format.

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F6	xxx	W
LU (word marks)				
A WDT				
WDTW (word marks)				

Function. This instruction causes the record data and addresses in core storage to be written on a disk track in the mode specified by the operation code (M or L). If the L operation code is used to write the track, word marks in the record area of core storage are written on the track.

The core-sector address must correspond to any one of the sector addresses on the track. The disk track is scanned for an address equal to the sector address in core storage. Writing the disk track begins when the track-index pulse is sensed (signaling first sector on track), if the address-compare operation results in an equal condition. If the result of the address-compare operation is unequal, the unequal-address compare indicator turns ON. All 20 sectors on the track, including the disk sector addresses, are written on disk storage. The sector-count field of the disk-control field must be set at 020 before the operation begins.

The core-sector address field is not modified by plus-one during this operation. To keep track of the number of sectors written, however, the sector-count field is modified by a minus for each sector read.

Word Marks. A group-mark with a word-mark must be one position to the right of the last character written on disk storage. This position can be found by adding 2130 to the B-address for operations performed with the M operation code, and 1930 for operations performed with the L operation code.

Timing. T = [N (L_I + 1) + 42] ms + disk rotation.*

*42 ms is maximum time for disk rotation.
22 ms is average time for disk rotation.
2 ms is minimum time for disk rotation.

Note: The write-address key-light on disk-storage-drive zero must be ON to perform this operation. When the key-light is OFF, disk-sector operations cannot be performed.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 9	B + 11 + 2120 (M Op code) or B + 11 + 1920 (L Op code)

Example. Write a disk track (with address) from the data in the area labeled WRTSAD (first position of data is at 1000). The disk control field is located in the ten positions preceding the label (0990-0999), Figure 30.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
3 5	6 7	8 13	14 16	17	23		27	28	34		36	39
0 1 0			MU	%F6				WRTSAD	-	10		W

Autocoder

Label	Operation	OPERAND
6 15	16 20	21 25 30 35 40 45 50
	WDT	WRTSAD-10

Assembled Instruction: M %F6 990 W

Figure 30. Write Disk Track Sectors with Addresses

Branch if Indicator On

The BRANCH IF INDICATOR ON instruction tests the indicators that might be set ON during a disk-storage operation. When a disk-storage instruction occurs in the program, it turns OFF all disk-storage indicators that were turned ON by a previous disk-storage operation. The execution of a disk-storage instruction can result in a disk-storage indicator being turned ON.

Instruction Format.

Mnemonic	*Op Code*	*I-address*	*d-character*
SPS B	B	xxx	x
A BIN			

Function. The d-character specifies the indicator tested.

If the indicator is ON, the next instruction is taken from the I-address. If the indicator is OFF, the next

sequential instruction is taken. Figure 31 shows symbols that are valid d-characters, and the indicators they test. More than one indicator can be turned ON as the result of a disk-storage operation.

Indicators: Access Inoperable—An access arm becomes inoperable if the logic safety circuit detects improper operation. A customer engineer can also render an arm inoperable. In either instance, this indicator turns ON when the program addresses the inoperable arm, at which time the operation is terminated and the next sequential instruction is started. At the same time, the RAMAC light turns ON.

The indicator also turns ON if an invalid (not installed) arm or disk-storage unit is addressed. Because the program continues in sequence even when an inoperable arm is addressed, a BRANCH IF INDICATOR ON instruction must immediately follow a seek instruction.

This indicator also turns ON if power is not supplied to the disk-storage unit addressed.

Disk Error. This indicator turns ON if even-bit parity occurs during reading or writing on a disk. Another condition that turns the indicator ON is an UNEQUAL COMPARE during a write-check operation. In this case the operation is completed.

Wrong-Length Record. This indicator turns ON if the following conditions are not satisfied: a group-mark with a word-mark in core storage is sensed at the same time as an end-of-sector and an all-zero condition in the sector-control field occurs. It also turns ON during a scan operation if the search argument is longer than, or equal to, a sector length. Detection of a wrong-length record terminates the operation and starts the next sequential instruction.

Unequal-Address Compare. An unequal-address compare condition occurs during the automatic comparison of the sector address in storage with the sector address on the disk. This unequal condition turns the unequal-address compare indicator ON after the disk track is scanned and the track-index pulse is sensed twice. Each sector operated on by a disk-storage read-write instruction is checked for ADDRESS COMPARE. This is an automatic check and does not have to be programmed. During multiple-sector operations, the indicator also turns ON after the data transfer begins when the sector address following a correct address comparison does not compare.

The internal circuitry is the same as that used by the COMPARE instruction. In programming, be careful that a normal-compare operation and the address-compare operation do not interfere with the settings of the equal-, low-, and high-compare indicators set by a previous instruction. Detection of an unequal-address compare terminates the operation and starts the next sequential instruction.

Any-Disk Condition. This indicator turns ON if any of the other disk-storage indicators are ON. It can be tested by the program, and, if it is OFF, the program can proceed. If this indicator is ON, then the other indicators should be checked to determine where corrective measures should be taken.

Access Busy. This indicator is turned ON if the access assembly is in motion when the program tries to execute a disk-storage instruction. The disk-storage instruction is terminated and the next sequential instruction is started. The indicator turns OFF when access-assembly motion stops and the program starts executing a disk-storage instruction.

d-Character	Indicator
N	Access Inoperable
V	Disk Error
W	Wrong-Length Record
X	Unequal-Address Compare
Y	Any Disk-Condition
\	Access Busy

Figure 31. d-Characters for BRANCH IF INDICATOR ON Instruction

Word Marks. Word marks are not affected.

Timing.

Without Indexing:

$T = N (L_I + 1)$ ms.

With Indexing:

$T = N (L_I + 2)$ ms.

Note: After each disk unit read or write operation, the program must test for error indications to prevent processing of unusable data.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	BI	d*bb*

Example. At the completion of a disk-read operation, test the any-disk-unit error condition indicator. If it is OFF, continue in the main program. If it is ON, branch to the routine labeled DISKER (0690) to determine the type of error condition. This tests all disk-unit indicators and branches to the error routine of the respective indicator that is on. The routines are labeled: ACINOP (0690), UNADCL (0695) WRLENR (0700), RWPARC (705), Figure 32.

IBM 1311 Disk Storage Drive Timing

The organization of data in disk storage and the method of processing data affect the seek time for a given operation and also affect the total systems' throughput. Some methods of seeking records and the sequence of disk storage and input/output instructions are considered here as an aid to program development.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	(A) OPERAND ±	(A) OPERAND CHAR. ADJ.	(A) OPERAND IND.	(B) OPERAND ADDRESS	(B) OPERAND ±	(B) OPERAND CHAR. ADJ.	(B) OPERAND IND.	d
0 1 0			B	D.I.S.K.E.R								Y
0 2 0												
0 3 0												
0 4 0		D.I.S.K.E.R	B	A.C.I.N.O.P								N
0 5 0			B	U.N.A.D.C.L								X
0 6 0			B	W.R.L.E.N.R								W
0 7 0			B	R.W.P.A.R.C								V
0 8 0												

Autocoder

Label	Operation	OPERAND
	B.I.N.	D.I.S.K.E.R,Y
D.I.S.K.E.R	B.I.N.	A.C.I.N.O.P,N
	B.I.N.	U.N.A.D.C.L,X
	B.I.N.	W.R.L.E.N.R,W
	B.I.N.	R.W.P.A.R.C,V

Assembled Instruction:

480	B	690	Y
690	B	740	N
695	B	790	X
700	B	890	W
705	B	990	V

Figure 32. BRANCH IF INDICATOR ON Testing Routine

Seeking Disk Storage Records

Two modes of operation for seek instructions are: *Return-to-Home* and *Direct Seek*, a special feature. The return-to-home mode is the standard mode of operation. In this mode, all seeks are achieved by first moving the access arms to a *home* position outside cylinder 00 and then counting into the desired cylinder. This function is automatically performed by the system. The direct-seek special feature enables the programmer to write the program so that the system can seek from one track to another track without requiring the access arms to return to home position.

Another factor to be considered in systems planning is that the access arms move at both a low speed and a high speed. Access-arm movement within ten cylinders is at low-speed rate of 2 inches per second. If more than ten cylinders are searched, the access arms move at the high-speed rate of 16 inches per second for all cylinders in excess of ten. These two speeds (2 inches and 16 inches per second) are not used by the programmer in timing disk-storage operations because the timing charts incorporate these variations in speed. Variation in speed is covered here so it can be considered when data is being organized in disk storage.

After a SEEK DISK instruction in either mode has been issued, processing can continue until another disk-storage instruction is issued. The length of the seek depends on the total number of cylinders that must be passed during the seek operation. Figure 33 provides actual seek time for cylinder-to-cylinder movement in increments of ten cylinders.

In the return-to-home mode, the total throughput time can be reduced by using a technique known as *dummy seek to cylinder 00.*

The total time for this operation is 106 ms, for approximately 2⅝ disk revolutions. The available processing time is 68 ms.

Processing time is reduced as more sectors are read or written. The timing for a 4-sector operation illustrates this point:

Read	2 ms head select delay time
	20 ms average rotational time
	8 ms to read four sectors
Process	30 ms processing
Write	2 ms head select delay time
	8 ms to write four sectors
Process	30 ms processing
Write Check	2 ms head select delay time
	8 ms write check
	110 ms Total

TO ↓ / FROM	00	09	19	29	39	49	59	69	79	89	99
00	75	88	101	114	127	140	153	167	179	192	204
09	175	188	201	214	227	240	253	267	279	292	304
19	143	156	169	182	195	208	221	235	247	260	272
29	153	166	179	192	205	218	231	245	257	270	282
39	168	181	194	207	220	233	246	260	272	285	297
49	184	197	210	223	236	249	262	276	288	301	313
59	200	213	226	239	252	265	278	292	304	317	329
69	215	228	241	254	267	280	293	307	319	332	344
79	232	245	258	271	284	297	310	324	336	349	361
89	248	261	274	287	300	313	326	340	352	365	377
99	263	276	289	302	315	328	345	355	367	380	392

Figure 33. Cylinder Seek Time—without Direct Seek

The total time in the preceding example is 110 ms (2¾ revolutions), only 4 milliseconds longer than the 2-sector operation. However, total processing time is 60 ms as opposed to 68 ms in the earlier example.

If possible, processing should be kept within the available rotational time. If not, the cycle is increased by one 40-ms revolution for each extension of available processing time.

Processing time between a write operation and a WRITE DISK CHECK instruction can be used for updating control totals and/or arranging fields of printing. When the print-storage special feature is installed, most disk operations may be completely overlapped by the printing operation.

DUMMY SEEK TO CYLINDER 00

Access motion time has two operations: *return-to-home* and *advance-from-home*. The return-to-home portion of access time normally can be overlapped if a SEEK TO CYLINDER 00 is issued before a card-read or -punch operation or a print operation (Figure 34).

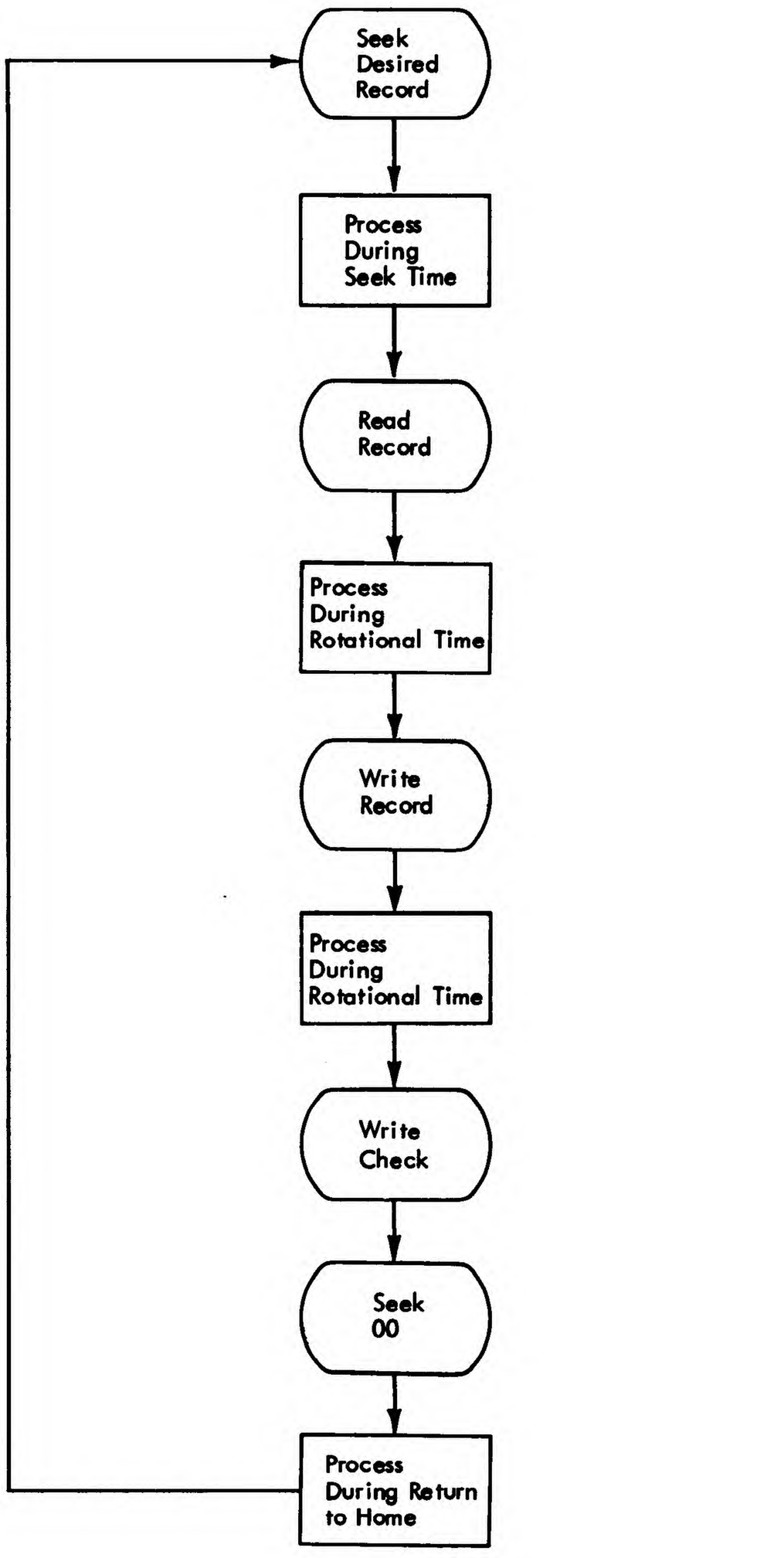


Figure 34. Block Diagram for Dummy Seek Technique

Timing Considerations for Reading and Writing

When designing a program utilizing the disk pack, the programmer should consider ways to place read, write, and write-check operations to save job time. Because the disks revolve at 1500 rpm, 40 ms are required to complete a revolution, and 2 ms to read or write one sector. The rotational time that must elapse before a disk operation can be executed should be utilized for processing, if possible.

Assume, for example, that a 2-sector record (200 characters) is to be read, updated, and then returned to the file. The timing chart and block diagram for this operation are shown in Figure 35.

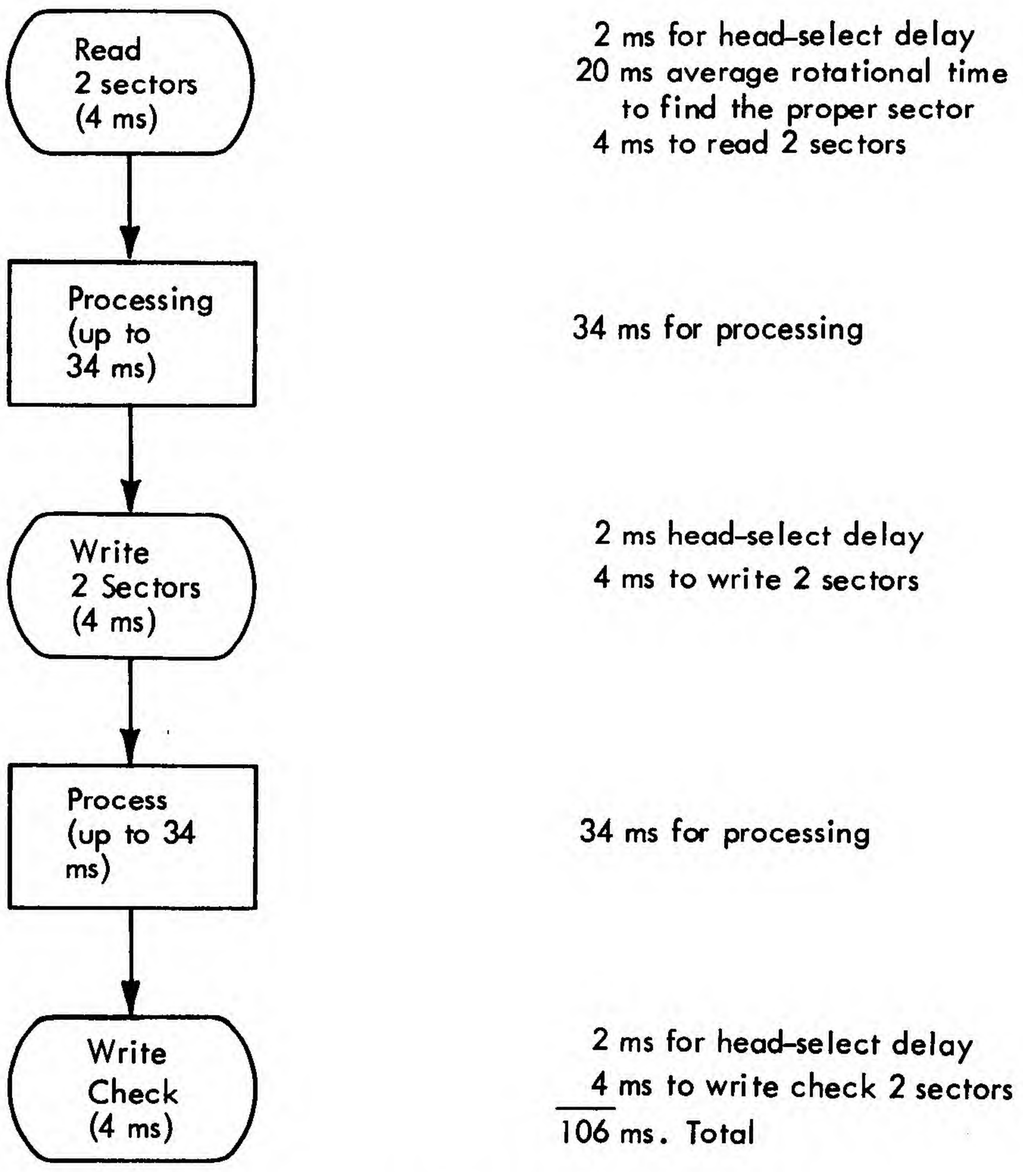


Figure 35. Disk-Storage Timing for a Two-Sector Record

A summary of the disk-storage times follows:

Rotational Delay	40 ms
Average Rotational Delay	20 ms
Head Select Delay	2 ms
Read One Sector	2 ms
Write One Sector	2 ms
Write Check One Sector	2 ms

Seek time—without direct access

Maximum	400 ms
Mean Seek Time	250 ms

Seek time—with direct access

Maximum	250 ms
Mean Seek Time	150 ms

IBM 1311 Error Routine

Figure 36 shows the correct method of programming input/output operations on the IBM 1311 Disk Storage Drive. The method presented in Figure 36 is, basically, the routine generated by the IBM 1440 and 1401/1311 Input/Output Control System. Explanation of the notes in Figure 36 are:

Note 1

Where possible, seek time should be utilized by including a processing routine in the busy loop.

Note 2

IOCS does not test for ANY DISK ERROR after the seek and write operations. If an error occurs at either of these points, it will be caught later. Tests for ANY DISK ERROR can be made after every BUSY test, however, and can often be justified by the ability to locate more easily the cause of the error.

Note 3

When the direct-seek special feature is used, the disk-control field contains a number equal to twice the number of cylinders to be crossed. If a number is used that causes the access mechanism to attempt to go past the last, or 100th cylinder, the disk drive will remain in a busy status until manually turned OFF and then back ON. In testing programs using the direct seek, it is recommended that the busy loops after all disk input/output instructions include a routine that will halt the system after a length of time has elapsed sufficient for the longest possible seek operation.

Note 4

Although not noted in this block diagram, the contents of the address registers at the time of a halt should uniquely identify the cause of the halt.

Note 5

The sequence of tests shown is justified by the fact that:

1. In the event of cylinder overflow, checking parity first ensures that the portion read or written is correct.
2. In the event of cylinder overflow, both the unequal-address compare and the wrong-length-record indicators are ON. If only the wrong-length-record indicator is ON, the error must be a true wrong-length-record error.

Note 6

If cylinder overflow is encountered, the three low-order digits of the address in the disk-control field will be 200, 400, 600, 800, or 000.

Note 7

None of the IBM programming systems will produce a block that overflows from one disk pack to another. However, IOCS can accommodate such a block in an input file. If the condition occurs when processing labeled files, the program must add 20 to the address in the disk-control field and change the drive number in the alternate-code position before branching to the seek instruction.

Note 8

When using the direct-seek special feature, the error routine should include a separate, return-to-home seek instruction instead of going back to the common SEEK DISK instruction of the main program. The reason for this is that when using the DIRECT SEEK, the program must be sure of the starting point of the seek. Because an error condition exists, assume that the program is not sure of the present position.

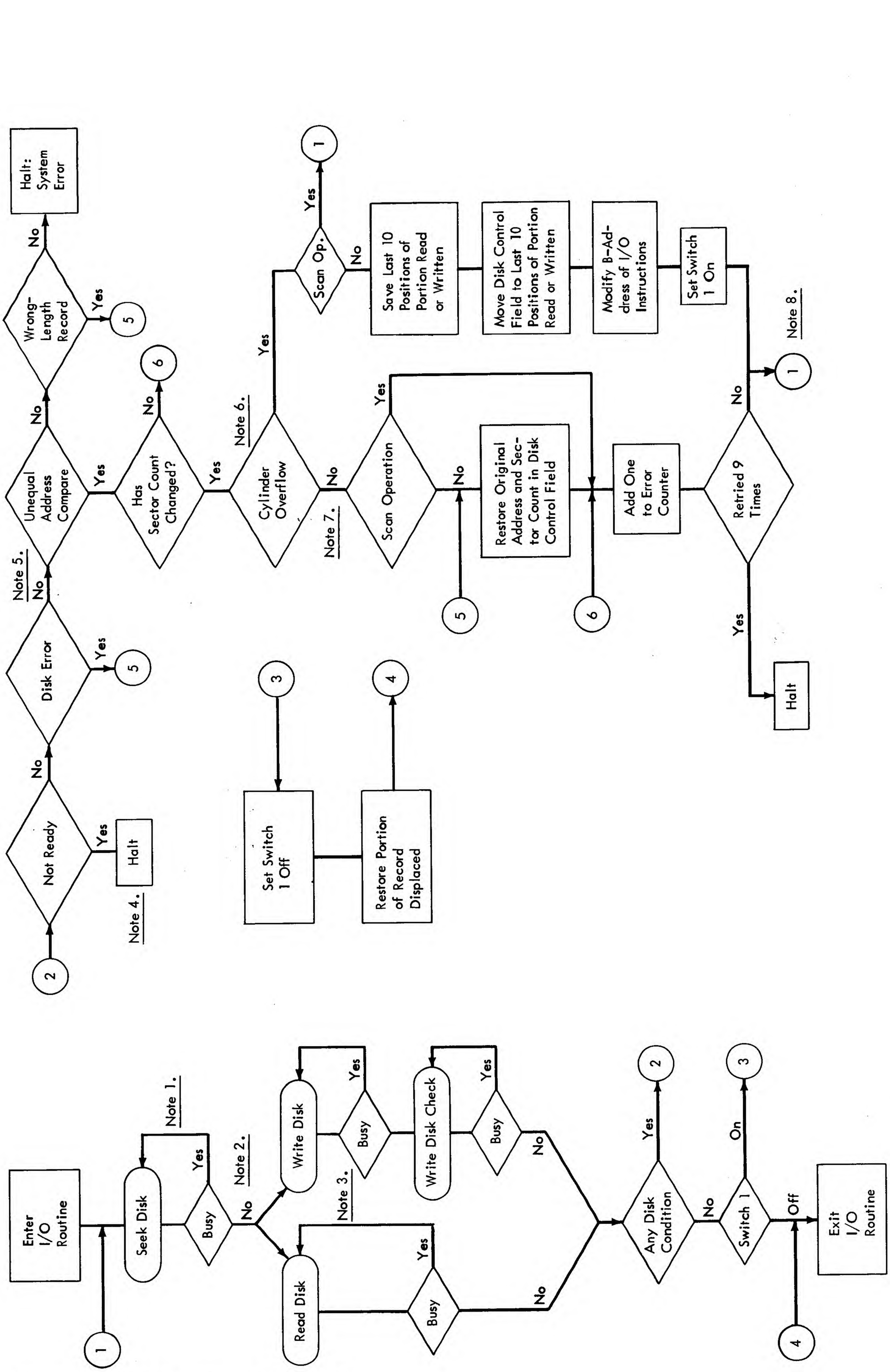


Figure 36. IBM 1311 Operation and Error Routine

The IBM 1301 Disk Storage, Models 11, 12, 21, 22 (Figure 37), provides the 1440 and/or 1460 system with the advantages of large capacity random access storage. As many as five IBM 1301 modules can be attached to a 1440 or 1460 system.

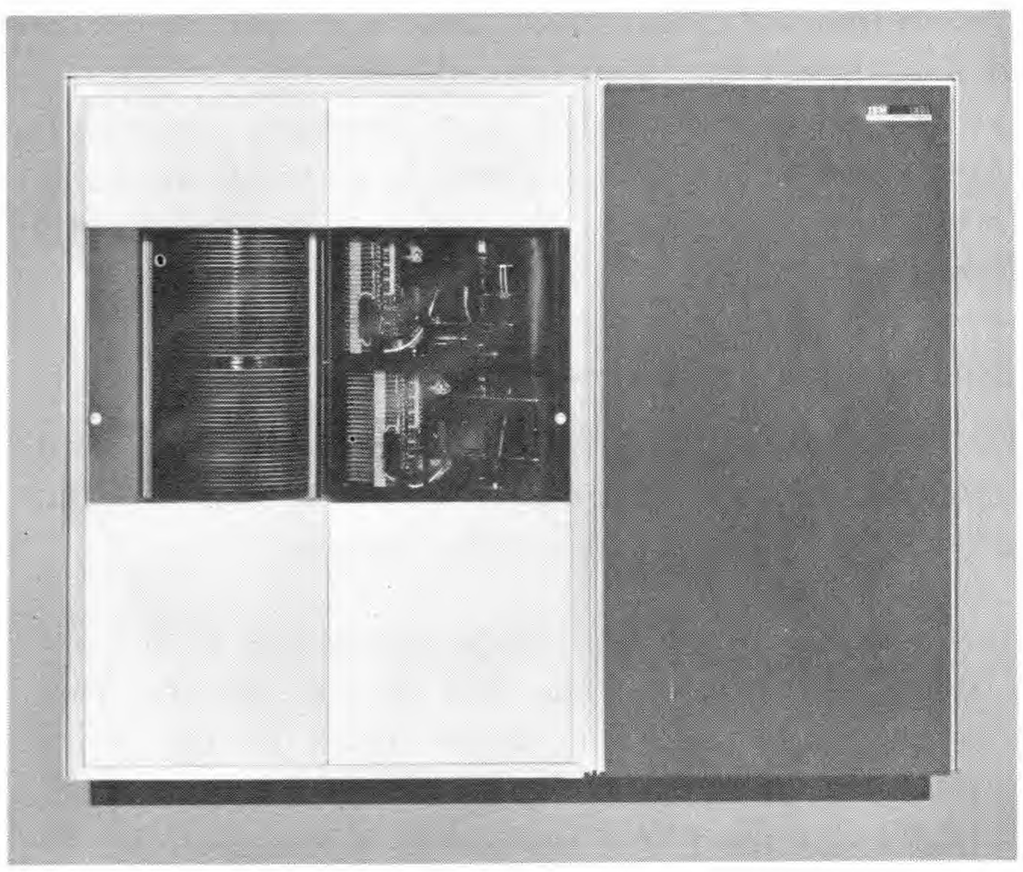


Figure 37. IBM 1301 Disk Storage

Disk-Control Field

A 10-digit disk-control field specifies the disk-storage area that is involved in the data transfer. This disk-control field is located in core storage, and begins at the core-storage address specified by the disk-storage instruction B-address. The data involved in the transfer follows the disk-control field (no data area is required for a seek-disk operation).

The various parts of the disk-control field are: alternate code, core sector address, and sector count (Figure 34).

Alternate Code	Core-Sector Address	Sector Count
x ⌑ or ≠,S,U,W,Y	xxxxxx 000000 - 999, 999	xxx 000 - 999

Figure 38. Disk-Control Field

Alternate Code

If a lozenge (⌑) is used in this position, the core sector address specifies the disk drive that will be selected.

A record mark (≠), S, U, W, or Y character in the alternate-code position is used to select a drive other than the drive specified by the sector address. The ≠, S, U, W, and Y characters select the first, second, third, fourth, and fifth disk modules respectively.

A word mark can be placed in the alternate-code position. The word mark does not affect the operation and is not lost. A 1-bit should never appear in the alternate-code position.

Core-Sector Address

The core-sector address contains the 6-digit address of the first sector to be operated upon. Before any disk operation is performed, an automatic comparison is made of the sector address in core storage with the disk-sector addresses on the specific track. If an equal comparison is made, the operation proceeds. If no equal comparison is made, the unequal-address compare indicator turns ON, and the disk operation is not performed. (When a multiple-sector operation is executed, only the address of the first-specified sector on each track involved in the operation is compared.)

When sector operations are performed, the core sector address is automatically increased by 1 immediately following the data transfer of each sector, except under these conditions:

1. Track operation being performed.
2. Sector-count field reaches the value of 000.
3. Wrong-length record.

When any of these conditions occur, the core-sector address is not increased by 1.

Notes:

1. The six positions of the 6-digit core-sector address may contain any valid character that has a numeric-bit value of zero through nine.
2. Zone bits over the core-sector address positions are lost if any address modification takes place.
3. Word marks in the core-sector address positions do not affect the operation, but are lost during any operation performed in the load mode that involves address modification.

Sector Count

This field indicates the number of sectors to be operated upon during the disk operation. The sector-count field is not used during a seek operation, but the positions must be there because the disk control field must be 10 positions long.

During the transfer of data to or from disk storage, the sector-count field is automatically decreased by 1 immediately following a successful address compari-

son, and before each additional sector is transferred. This operation results in the sector-count field reflecting the number of sectors transferred.

If a sector count of 000 is used when initiating a disk sector read or write operation, an error condition occurs. Before the first sector is transferred, a 1 is subtracted from the sector-count field. In this case, the result would be 999. Therefore, data would be transferred until a group-mark with a word-mark is encountered in core storage. Because the sector count is not zero at this time, the wrong-length record and any-disk condition indicators would be turned ON.

Notes:

1. Word marks cannot be placed over the sector-count field units position. Word marks in any other position do not affect the operation, but are lost during any operation performed in the load mode that affects sector-count modification.
2. Zone bits are always removed from all three positions of the sector-count field.

Basic Disk Operations

The four basic operations performed by the 1301 are seek, read, write, and write disk check.

Seek Operation

The seek operation is initiated by a SEEK DISK instruction, which directs the read/write heads to the proper cyilnder on the disk drive. This instruction is followed by a read or write operation.

The data on the disk records is not acted on during this seek operation.

The seek operation positions the access arms over the specified cylinder. The B-address position of the instruction contains the core-storage address of the disk-control field and it is this field that specifies the proper cylinder plus other pertinent information.

Read Operation

The read operation is initiated by one of the three different types of READ DISK instructions, and transfers data from disk storage to a specified area in core storage. (The three types of instructions are discussed following the write-operation description.) The specified disk-storage area involved in the transfer is partially identified by the previous seek operation, and the rest of the area is fully identified before the data transfer takes place. The identification is accomplished by comparing the sector addresses on the disk with the sector address in core storage. The sector address in core storage is part of the disk-control field, and the B-address position of the READ DISK instruction contains the core-storage address of the disk-control field. The data from the disk is placed in a core-storage area located immediately to the right of the disk-control field.

Write Operation

The write operation is initiated by one of the three different types of WRITE DISK instructions, and transfers data from a specified core-storage area into disk storage. (The three types of instructions are discussed following this operation description.) The specific disk-storage area involved in the transfer is partially identified by the previous seek operation, and the rest of the area is fully identified before the data transfer takes place. The identification is accomplished by comparing the sector addresses on the disk with the sector address in core storage. The sector address in core storage is part of the disk-control field, and the B-address portion of the WRITE DISK instruction contains the core-storage address of the disk-control field. The data that will be transferred to the disk is stored in a core-storage area located immediately to the right of the disk-control field.

TYPES OF READ AND WRITE OPERATIONS

Each read or write operation can operate in three different ways, or modes: sector, track sectors with addresses, and sector-count overlay modes.

Sector Mode. Read and write operations in the sector mode transfer data, but do not transfer disk-sector addresses. The sector mode is the normal mode of operation. The number of sectors to be handled during one operation is specified by the sector-count portion of the disk-control field. Each sector is transferred only after a correct comparison of the sector address in the core-storage disk-control field is made with the initial sector address on each track of the disk. For more detailed information, refer to the specific instruction.

Track Sectors with Addresses Mode. This mode of operation transfers both the data and the disk-sector addresses to and from the disk, one complete track at a time. The mode of operation makes it possible to change the previously recorded sector addresses. The operation requires that the sector-address portion of the disk-control field contain the address of one of the sectors within the specified track, and the sector-count portion of the disk-control field must contain 020 (20 sectors will be transferred). The transfer can occur only after a correct comparison of the sector address in the core-storage disk-control field with a sector address on the specified track. For more detailed information, refer to the specific instruction.

Sector-Count Overlay Mode. This mode of operation allows a portion of the data record itself to specify the number of sectors that will be involved in the data transfer. The disk-sector addresses are not part

of the transfer. This mode of operation permits better disk-storage utilization for sequential applications involving variable-size records. For more detailed information, refer to the specific instruction.

Reading and Writing with Word Marks. Word marks can be transferred with the data during all reading and writing operations by an L Op code instead of an M Op code. When word marks are written on the disk, the data is written in an 8-bit BCD coding.

Write Disk Check

The write-disk-check operation causes the data in the specified disk area to be compared against the comparable data in the specified core-storage area. When the disk data does not compare, bit-by-bit and character-by-character, with the core-storage data, a disk-error indicator is set ON. This operation takes the form of a WRITE DISK CHECK instruction, which normally must follow each write operation. The write-disk-check operation compares the data written in disk storage with the original source data in core storage.

1301 Instruction Format and Instructions

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
xx *	M/L	%Fx	xxx	R/W

*Mnemonics for SPS shown with the instruction formats apply to the IBM 1460 system, and Autocoder mnemonics apply to the IBM 1440 and 1460.

Op Code

This is always a single character that defines the basic operation to be performed. Either the M or L operation code can be used with IBM 1301 instructions.

When the M Op code is used, characters are written or read in 7-bit mode (CBA 8421). The sector character capacity in the 7-bit mode is 100 characters. The L Op code causes characters to be read or written in 8-bit mode (CBA 8421 M). The 8-bit mode provides for a possible word mark with the character being written on, or read from, the disk record. The sector character capacity in the 8-bit mode is 90 characters.

A-Address

%Fx signals that the disk unit is to be selected; x represents the digit used to perform various operations.

X-Position	*Operation*
0	Seek a disk record.
1	Sector—Reading or writing characters from the number of sectors specified by the sector-count field is stopped when a group-mark a word-mark, or the end-of-sector, is sensed. If a group-mark with a word-mark is sensed before the reading of the sector(s) is completed, reading stops and the wrong-length record and any-disk condition indicators turn ON. If the group-mark with a work-mark is sensed before the writing of a record on a disk is completed and it is before the end of a record, the remainder of the disk record is filled with valid blanks (C-bit), and the any-disk condition and wrong-length-record indicators are turned ON.
6	Disk Track-Sector with Addresses—Allows the reading or writing of a full track (20 sectors) including sector addresses.
3	Write Disk Check—Data written on a disk in a preceding write operation is read from the disk and compared, character-by-character, with the data in core storage. A WRITE DISK CHECK instruction must be given following a write operation, unless an error occurred *during* the write operation. A write-disk-check operation can be executed after a read operation if a check on the information read is desired. The operation is performed exactly the same as a write-disk-check operation following a write operation.
5	Sector-Count Overlay—Allows for records of a variable number of sectors (more than one) to be read or written with a single instruction. The number of sectors to be read/written is controlled by the multiple sector-count field. This control field is in the first three data positions of the first sector of the disk record. This technique permits better disk storage utilization for sequential applications involving variable-size records. The record itself specifies the number of sectors involved.

B-Address

The B-address specifies the high-order position in core storage of the 10-digit disk-control field. The disk-control field is followed by the area of core storage that is to have data read into or out of by a group-mark with a word-mark.

d-Character

The d-character is used to specify the operation to be performed. The d-character R specifies a read operation; the d-character W specifies a write operation.

Seek Disk

Instruction Format

	Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS	MU or LU	M or L	%F0	xxx	R
A	SD				

Function. The A-address specifies that a seek operation is to be performed by the access assembly. The B-address specifies the high-order position in core storage of the disk-control field. Only the alternate-code position and the six-position core-sector address are used during a seek-disk operation, but the disk-control field must be 10 positions long.

The selected access assembly moves from the old setting directly to the new setting. The functions associated with the direct-seek special feature are standard in the 1301.

Word Marks. Word marks are not affected.

Timing. T = N* (L_I + 7) ms + access time.
180 ms is maximum access time for a seek.
160 ms is average access time for a seek.
0 ms if access mechanism is at track (SEEK DISK instruction not given).
*N = .0111 for 1440; .006 for 1460.

Note: If the access mechanism is already at the disk track that is to be used, a SEEK-DISK instruction need not be given.

Address Registers After Operation.

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 7

Example. Seek record 015734 with the access assembly. Storage locations 0590-0599 (labeled INPUTA) contains 0015734001 (Figure 39).

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	d
3 5	6 7	8 13	14 16	17 23		27	28 34		36	39
0 1 0			MU	%F0			INPUTA	-	10	R

Autocoder

Label	Operation	OPERAND
6 15	20 21 25 30 35 40 45 50	
	SD	INPUTA-10

Assembled Instruction: M %F0 590 R

Figure 39. Seek Disk

Sector Operations

If only the data portion of a disk record is to be affected, the operation is classified as a *sector operation* (addresses are not affected). Disk records can be read, written, or scanned during *sector operation*. The term *sector operation* does not mean that a disk record is confined to a 100-character sector. The data needed for a record can be written in as many sectors as needed.

Read Disk Sector(s)

Instruction Format

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU A RD	M	%F1	xxx	R

Function. This instruction causes data to be read from disk storage into core storage. The digit 1 in the A-address (%F1) specifies that a sector operation is to be performed. The number of sectors to be read is specified by the sector-count field. The reading of the disk is stopped by a group-mark with a word-mark in core storage and by the end of the sector.

Reading begins at the address contained in the core-sector address field and continues for the number of sectors specified by the sector-count field.

The core-sector address field is *increased* by one for each sector read, and the sector-count field is *reduced* by one as a sector is read.

When the sector-count field reaches 000, an end of operation is indicated to the system. An error condition results from any disk-sector read or write operation that begins the operation with a sector count of 000. Before the first sector is transferred, a one (1) is subtracted from the sector-count field, resulting in a sector count of 999. Data would then be transferred until a group-mark with a word-mark is encountered in core storage. Because the sector count is not zero at this time, the wrong-length record and any-disk condition indicators are turned ON.

The B-address specifies the high-order position in core storage of the disk-control field, and the area in storage reserved for the data read from the disk.

The R in the d-character position signifies a read operation.

Word Marks. A group-mark with a word-mark must be one position to the right of the last position reserved in core storage for the disk record. If a group-mark with a word-mark is detected before reading of the record is completed, the wrong-length-record indicator turns ON and reading stops. The position of the group-mark with a word-mark can be determined by using the formula:

$$GM\text{-}WM = B + N_S(L_S) + 10$$

B = Address of high-order position of disk address in core storage.
N_S = Number of sectors read.
L_S = Number of characters per sector.

Timing. T = N (L_I + 1) ms + 1.7N_S + disk rotation.*
*35 ms is maximum time for disk rotation.
18.4 ms is average time for disk rotation.
1.7 ms is minimum time for disk rotation.

Note: Before reading starts, an automatic comparison is made of the core-sector address with the sector address on the disk. This check is made for the first sector on each track involved in the operation. If they are not the same, the unequal-address compare indicator turns ON, and the data on the disk cannot be read into storage.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 11 + N_SL_S (no overlay)

Example. Read one sector from disk storage into core storage beginning at location 0600 (labeled INPUTA). The disk-control field is in the ten positions preceding the label (0590-0599), Figure 40.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	d
0,1,0			MU	%F1			INPUT,A-1,0			R

Autocoder

Label	Operation	OPERAND
	RD	INPUT,A-1,0

Assembled Instruction: M %F1 590 R

Figure 40. Read Disk Sector

Read Disk Sector(s) with Word Marks

Instruction Format

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS LU	L	%F1	xxx	R
A RDW				

Function. This is similar to the READ DISK SECTOR instruction except that (1) word marks in the record area of core storage are removed, and (2) word marks from the disk record are written in core storage. The length of the sector read from disk storage into core storage is 90 positions.

Word Marks. A group-mark with a word-mark in core storage terminates the read operation. If the group-mark with a word-mark is not in the position to the right of the last character read from the disk into core storage, the wrong-length-record and any-disk condition indicators turn ON.

Timing. $T = N (L_I + 1)$ ms $+ 1.7N_S +$ disk rotation.*

*35 ms is maximum time for disk rotation.
18.4 ms is average time for disk rotation.
1.7 ms is minimum time for disk rotation.

Note: If a disk is read in a mode dlifferent from the one in which it was written (M or L operation code), a parity error occurs. The disk-error indicator turns ON.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 11 + N_SL_S (no overlay)

Example. Read a record, with its associated word marks, from disk storage into the area labeled INPUT (first position of data is at 0600). The disk-control field is located in the ten positions preceding the label (0590-0599), Figure 41.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	d
0,1,0			LU	%F1			INPUT,	-	1,0	R

Autocoder

Label	Operation	OPERAND
	RDW	INPUT,-1,0

Assembled Instruction: L %F1 590 R

Figure 41. Read Disk Sector with Word Marks

Read Disk with Sector-Count Overlay

Instruction Format

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F5	xxx	R
LU (word marks)				
A RDCO				
RDCOW (word marks)				

Function. This operation is similar to the read-disk-sector(s) instruction except that the number of sectors to be read is controlled by the first three positions in the first record read. The digit 5 in the A-address specifies that an overlay operation is to be performed.

As the first sector is read from disk storage, the first three digits of the record being read are placed in the sector-count field of the disk-control field in core storage. Therefore, if a variable number of sectors are to be read from disk storage, the sector-count field must contain a value greater than 001 to cause the first sector to be read. The first three positions of the first sector read contain the number of additional sectors to be read. Figure 42 illustrates the operation of an overlay instruction, which causes four sectors of data to be read from disk storage into core storage.

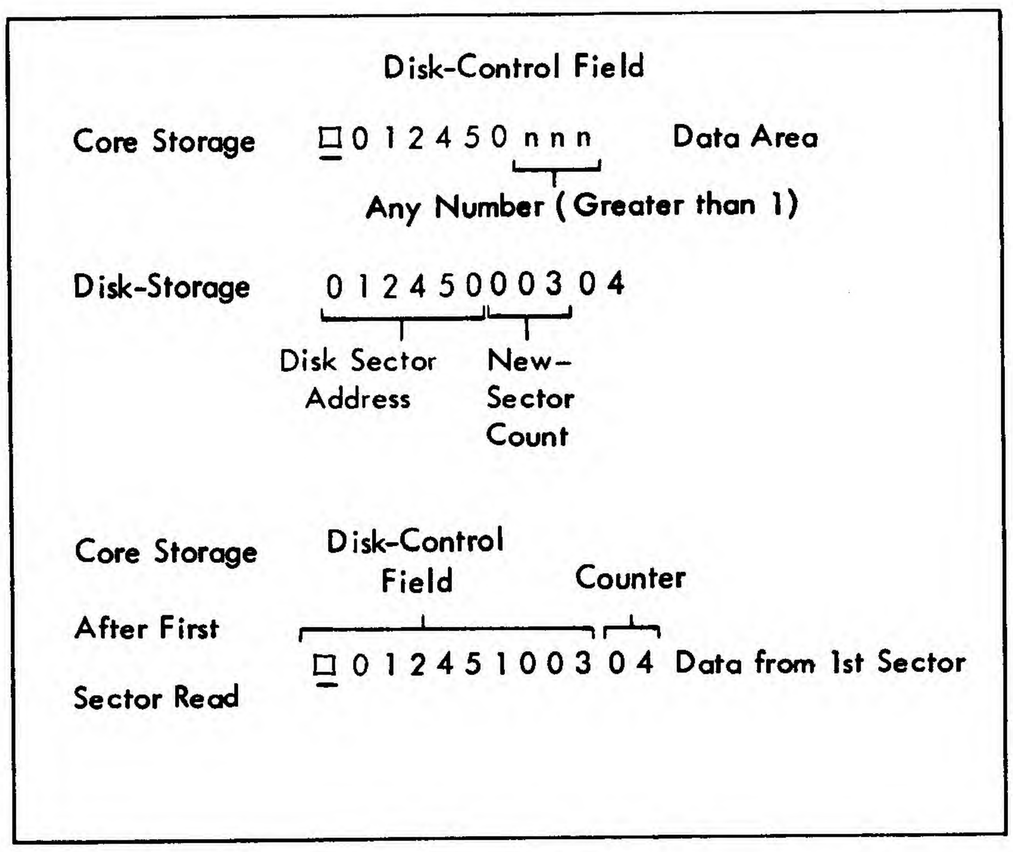


Figure 42. Read Disk—Sector-Count Overlay Operation

The operation proceeds as a normal read operation with appropriate changes to the core-sector address and sector-count fields.

Word Marks. If the exact number of positions of data to be read from disk storage is not known when this operation is initiated, place the group-mark with a word-mark (signalling the end-of-operation) one position to the right of the last possible character to be read using this instruction. If the maximum num-

ber of records is not read, the read into storage stops because the end-of-sector is reached and the sector-count field is all zeros before the group-mark with a word-mark is sensed. The wrong-length-record indicator also turns ON. The programmer can check core storage in this case to see if the correct number of sectors have been read.

This can be accomplished by setting up a counter in the fourth and, if necessary, fifth position of the first sector of the record. This counter, when the read operation is completed, is located in the first and/or second position of the data record in core storage. These positions can be used to check the number of sectors in the record. These counter positions should equal the number of sectors read. Therefore, data reading should have stopped at $B + 6 + N_S L_S$. If it did not, then an error did occur and appropriate action should be taken. If a correct read has occurred, the error indication can be disregarded.

Timing. $T = N (L_I + 1) + 1.7N_S$ + disk rotation*.

*35 ms is maximum time for disk rotation.
18.4 ms is average time for disk rotation.
1.7 ms is minimum time for disk rotation.

Notes:

1. Before reading starts, an automatic comparison is made of the sector address in core storage with the sector address on the disk. This check is made for the first sector on each track involved in the operation. If the addresses are not the same, the unequal-address compare indicator is turned ON, and the data on the disk cannot be read into storage.
2. Special consideration must be given to single-sector records read in the sector-count overlay mode. When the read operation begins, the first three data characters of the record overlay the sector-count portion of the disk-control field. When a single-sector operation is specified, 000 is read in and overlaid in the sector-count positions. The system-detection circuits only detect a zero sector count when it is produced by automatically decreasing the sector-count field, however. After reading the single-sector record, the read operation does not end. The sector address is increased by one, and the sector-count field is decreased by one, resulting in a sector count of 999. The read operation continues until a group-mark with a word-mark is sensed. Because the sector-count field will not contain all zeros at the end of the operation, the wrong-length-record and any-disk indicators are turned ON.

   If a disk drive includes single-sector records, a special routine must be included to verify the validity of the record read. Before execution of a read operation, a special character that would never be found in the last position of a record can be moved to the 100th position of the core-storage input area. The wrong-length-record routine can then check to see whether the counter in the first position of the record contains a one (1). If it does, the routine would look to see that the special character has been overlaid in core storage. If it has been, the record was read in its entirety.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	$B + 8 + N_S L_S$

Example. Read into core storage a variable number of sectors that contain the data for a record beginning at location 0900 (labeled INPUTB). The disk-control field address is located in the ten positions preceding the label (0890-0899), Figure 43.

SPS

LINE (1-5)	COUNT (6-7)	LABEL (8-13)	OPERATION (14-16)	(A) OPERAND ADDRESS (17-23)	(A) OPERAND ± (24)	(A) OPERAND CHAR. ADJ. (25-27)	(B) OPERAND ADDRESS (28-34)	(B) OPERAND ± (35)	(B) OPERAND CHAR. ADJ. (36-38)	d (39)
0 1 0			M U	%F5			I N P U T B -	1 0		R

Autocoder

Label (1-15)	Operation (16-20)	OPERAND (21-50)
	R D C O	I N P U T B - 1 0

Assembled Instruction: M %F5 890 R

Figure 43. Read Disk with Sector-Count Overlay

Write Disk Sector(s)

Instruction Format

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU *A* WD	M	%F1	xxx	W

Function. This instruction causes record data in core storage to be written on a disk record. The digit 1 in the A-address (%F1) specifies that a sector operation is to be performed. The number of sectors to be written is specified by the sector-count field. The writing of the disk record is stopped by a group-mark with a word-mark in core storage and by the end-of-sector.

Writing begins at the address contained in the core-sector address field and continues for the number of sectors specified by the sector-count field.

The core-sector address field is *increased* by one for every sector written. The sector-count field is *reduced* by one as a sector is written.

When the sector-count field reaches 000, an end-of-operation is indicated to the system. An error condition results from any disk sector read or write operation that begins the operation with a sector count of 000. Before the first sector is transferred, a one (1) is subtracted from the sector-count field, resulting in a sector count of 999. Data would then be transferred until a group-mark with word-mark is encountered in core storage. Because the sector count is not zero at this time, the wrong-length-record and any-disk-condition indicators are turned ON.

The B-address specifies the high-order position in core storage of the disk-control field, and is followed by the data to be written on the disk.

The W in the d-character position signifies a write operation.

Word Marks. A group-mark with a word-mark must be *one* position to the right of the last character of the record in core storage. The writing of data stops when the end-of-record is reached on the disk and a group-mark with a word-mark sensed in core storage. If the group-mark with a word-mark is sensed before the end of a record, the remainder of the disk record is filled with valid blanks (C-bit), and the any-disk-condition and wrong-length-record indicators are turned ON. The position of the group-mark with a word-mark can be determined by using the formula:

GM-WM = B + N_S (L_S) + 10

Timing. T = N (L_I + 1) ms + 1.7 N_S + disk rotation.*

*35 ms is maximum time for disk rotation.
18.4 ms is average time for disk rotation.
1.7 ms is minimum time for disk rotation.

Notes: Before writing starts, an automatic comparison is made of the core-sector address with the record address on the disk. This check is made for the first sector on each track involved in the operation. If the addresses are not the same, the unequal-address compare indicator is turned ON, and the data in storage cannot be written on the disk.

If the data in core storage contains characters with word marks, only the CBA8421 portion of the character is written on the disk (the word mark is ignored).

A write-disk-check instruction must be performed following a write-disk operation unless an error occurred during the write operation. No other disk-storage operation can be performed until the check of data written on the disk is accomplished.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 11 + N_SL_S (no overlay)

Example. Write a disk record (one sector) from the data in the area labeled INPUTA (first position of data is at 0600). The disk-control field is located in the ten positions preceding the label (0590-0599), Figure 44.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	d
0	0		MU	%F1			INPUTA-		10	W

Autocoder

Label	Operation	OPERAND
	WD	INPUTA-10

Assembled Instruction: M %F1 590 W

Figure 44. Write Disk Sector

Write Disk Sector(s) with Word Marks

Instruction Format

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS LU	L	%F1	xxx	W
A WDW				

Function. This instruction is similar to the write-disk-sector instructon, except that word marks set with the data in core storage are recorded on the disk record. This mode of operation permits writing programs on disk records for system use. Ninety positions of data with word marks are recorded on each sector during the write operation.

Word Marks. A group-mark with a word-mark one position to the right of the last character of the record in core storage terminates the write operation. If the group-mark with a word-mark is not sensed at the same time as the end of a record, the remainder of the disk record is filled with valid blanks (C-bit), and the any-disk-condition and the wrong-length-record indicators are turned ON.

Timing. T = N (L_I + 1) ms + 1.7N_S + disk rotation.*

*35 ms is maximum time for disk rotation.
18.4 ms is average time for disk rotation.
1.7 ms is minimum time for disk rotation.

Notes: The programmer should be certain that all records on a specific track are written in the same mode (M or L operation code). Otherwise, track operations are not possible.

Before writing starts, an automatic comparison is made of the record address in storage with the record address on the disk. If the addresses are not the same, the unequal-address compare indicator is turned ON, and the data in storage cannot be written on the disk. A write-disk-check operation must be performed following this instruction.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	B + 11 + N_SL_S (no overlay)

Example. Write a disk record, with word marks, from the data in the area labeled OUTPUT (first position of data is 0600). The disk control field is located in the ten positions preceding the label (0590-0599), Figure 45.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	d
0	0		LU	%F1			OUTPUT-		10	W

Autocoder

Label	Operation	OPERAND
	WDW	OUTPUT-10

Assembled Instruction: L %F1 590 W

Figure 45. Write Disk Sector with Word Marks

Write Disk with Sector-Count Overlay

Instruction Format

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F5	xxx	W
LU (word marks)				
A WDCO				
WDCOW (word marks)				

Function. This operation is similar to the WRITE DISK SECTOR instruction except that the sector-count field of the disk-control field is automatically decreased by one and then written in the first three data positions of the first sector written. The digit 5 in the A-address specifies that an overlay operation is to be performed.

Therefore, the sector-count field in core storage should contain the number of sectors to be written. The first three data positions of the first sector written contain the number of additional sectors that were written. Figure 46 illustrates the operation of an overlay instruction, which causes four sectors of data to be written from core storage onto disk storage.

The operation proceeds as a normal write operation with appropriate changes to the core-sector address and sector-count fields.

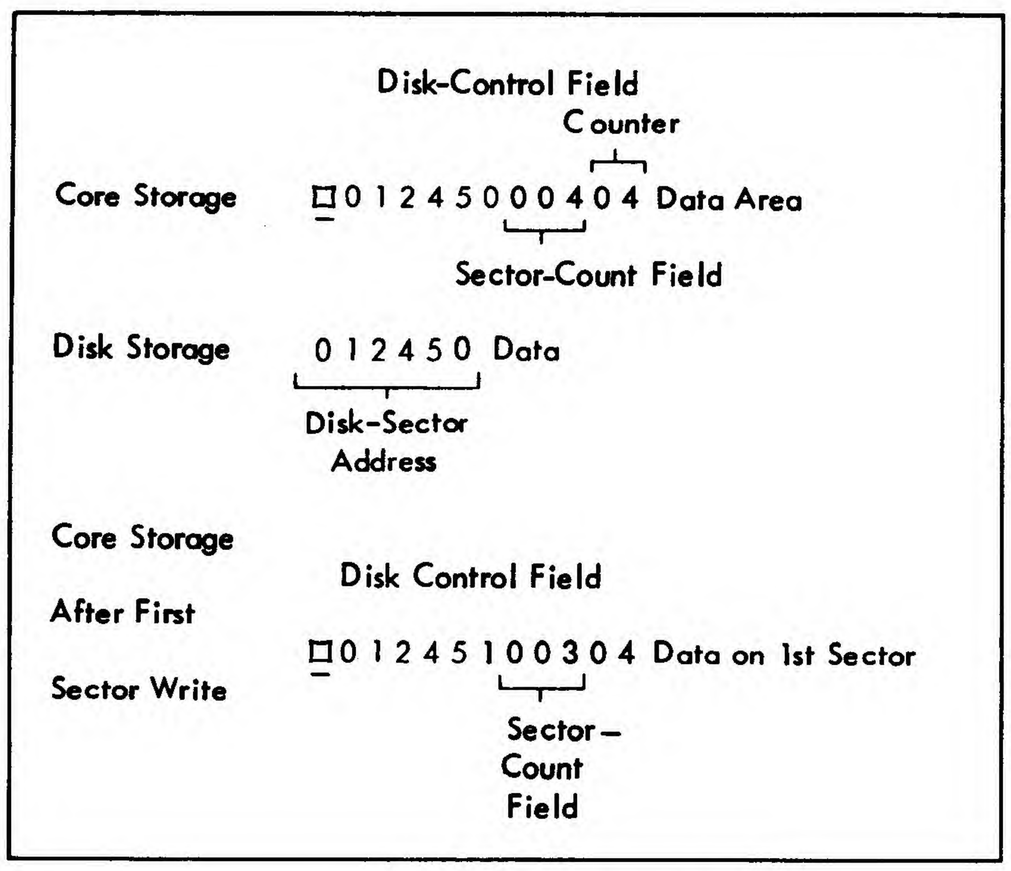


Figure 46. Write Disk—Sector-Count Overlay Operation

Word Marks. A group-mark with a word-mark should be placed one position to the right of the last sector to be written. The group-mark with word-mark must be placed at $B + 7 + N_S L_S$ to avoid a false wrong-length-record indication.

Timing. $T = N (L_I + 1)$ ms $+ 1.7N_S +$ disk rotation.*

*35 ms is maximum time for disk rotation.
18.4 ms is average time for disk rotation.
1.7 ms is minimum time for disk rotation.

Note: Before writing starts, an automatic comparison is made of the record address in core storage with the record address on the disk. This check is made before the first sector on each track involved in the operation. If the addresses are not the same, the unequal-address compare indicator is turned ON, and the data in core storage cannot be written in disk storage.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 6	$B + 8 + N_S L_S$

Example. Write a number of sectors for a record on disk storage that contains data beginning at location 0900 (labeled OUTPUT). The disk-control field is located in the ten positions preceding the label (0890-0899), Figure 47.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
3 9	6 7	8 13	14 16	17	23		27	28	34		36	39
0 . . 0			MU	%F5				OUTPUT-10				W

Autocoder

Label	Operation	OPERAND
6 15	19 20	21 25 30 35 40 45 50
	WDCO	OUTPUT-10

Assembled Instruction: M %F5 890 W

Figure 47. Write Disk with Sector-Count Overlay

Write Disk Check

Instruction Format

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F3	xxx	W
LU (word marks)				
A WDC				
WDCW (word marks)				

Function. This instruction causes a comparison, character-by-character, of the data in core storage with the data just written on the disk. This instruction must be executed after a write operation and before any other disk-storage operation is initiated.

The digit 3 in the A-address specifies that a WRITE DISK CHECK is to be performed. Either an L or M operation code is used, depending on how the data was recorded in disk storage.

The B-address specifies the area in core storage that contains the disk-control field and the data recorded on the disk.

The sector-address and sector-count fields of the sector-control word must be restored to the values present at the beginning of the write operation.

Word Marks. A group-mark with a word-mark must appear one position to the right of the disk data in core storage.

Timing. $T = N (L_I + 1)$ ms $+ 1.7N_S +$ disk rotation time.*

*35 ms is maximum time for disk rotation.
18.4 ms is average time for disk rotation.
1.7 ms is minimum time for disk rotation.

Notes: If the disk address in core storage is not the same as the address on the record, the unequal-address compare indicator turns ON. If any of the characters on the disk record do not agree with the characters in core storage, the disk-error indicator turns ON.

A write-disk-check operation can be executed after a read operation if a check on the information read is desired. The operation is performed exactly the same as a write-disk check-operation following a write operation.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	Depends on previous operation	

Example. Compare the disk record with a record in core-storage area labeled OUTPTC (beginning at 0700). The disk-control field is located in the ten positions preceding the label (0690-0699), Figure 44.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
3 5	6 7	8 13	14 16	17	23		27	28	34		36	39
0 1 0			M,U,	%F3				O,U,T,P,T,C	-	1,0		W

Autocoder

Label	Operation	OPERAND
6 15	16 20	21 25 30 35 40 45 50
	W,D,C,	O,U,T,P,T,C,-1,0

Assembled Instruction: M %F3 690 W

Figure 48. Write Disk Check

Address Operations

The ability to read and/or alter disk addresses is conditioned by certain IBM 1440/1460-1301 instructions. These instructions contain the term *Address* in their description.

If the proper instruction is not used when trying to perform an address operation, the system stops and the RAMAC light on the system console turns ON.

Read Disk Track Sectors with Addresses

Instruction Format

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F6	xxx	R
LU (word marks)				
A RDT				
RDTW (word marks)				

Function. This instruction causes the contents of an entire disk track (addresses and data) to be read in the mode specified by the operation code M or L. If the L operation code is used, the track is read into storage with its associated word marks.

The core-sector address must correspond to any one of the sector addresses on the track. The disk track is scanned for an address equal to the sector address in core storage. The disk-track reading begins when the first track-index pulse following a successful address-compare operation is sensed. If the result of the address-compare operation is unequal, the unequal-address compare indicator turns ON. All twenty sectors on the track, including the disk-sector addresses, are read into core storage. The sector-count field of the disk address must be set at 020 before the operation begins.

The core-sector address field is not modified by plus-one during this operation. To keep track of the number of sectors read, however, the sector-count field is modified by minus-one for each sector read.

Word Marks. A group-mark with a word-mark must be placed one position to the right of the last character read into core storage. This position can be found by adding 2130 to the B-address for operations performed with the M operation code, and 1930 for operations performed with the L operation code.

Timing. T = [N (L_I + 1) + 33.3] ms + disk rotation.*

*35 ms is maximum time for disk rotation.
18.4 ms is average time for disk rotation.
1.7 ms is minimum time for disk rotation.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 9	B + 11 + 2120 (M Op code) or B + 11 + 1920 (L Op code)

Example. Read disk track 17550, with its associated word marks, into the core-storage area labeled RDTSAD (first position of data is at 0800). The disk-control field is located in the ten positions preceding the label (0790-0799), Figure 49.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
3 5	6 7	8 13	14 16	17	23		27	28	34		36	39
0 1 0			M,U,	%F6				R,D,T,S,A,D	-	1,0		R

Autocoder

Label	Operation	OPERAND
6 15	16 20	21 25 30 35 40 45 50
	R,D,T,	R,D,T,S,A,D,-1,0

Assembled Instruction: M %F6 790 R

Figure 49. Read Disk Track Sectors with Addresses

Write Disk Track Sectors with Addresses

Instruction Format

Mnemonic	*Op Code*	*A-address*	*B-address*	*d-character*
SPS MU	M or L	%F6	xxx	R
LU (word marks)				
A WDT				
WDTW (word marks)				

Function. This instruction causes the record data and addresses in core storage to be written on a disk track in the mode specified by the operation code (M or L). If the L operation code is used to write the track, word marks in the record area of core storage are written on the track.

The core-sector address must correspond to any one of the sector addresses on the track. The disk

track is scanned for an address equal to the sector address in core storage. Writing the disk track begins when the track-index pulse is sensed (signaling first sector on track), if the address-compare operation results in an equal condition. If the result of the address-compare operation is unequal, the unequal-address compare indicator turns ON. All 20 sectors on the track, including the disk sector addresses, are written on disk storage. The sector-count field of the disk-control field must be set at 020 before the operation begins.

The core-sector address field is not modified by plus-one during this operation. To keep track of the number of sectors written, however, the sector-count field is modified by a minus for each sector read.

Word Marks. A group-mark with a word-mark must be one position to the right of the last character written on disk storage. This position can be found by adding 2130 to the B-address for operations performed with the M operation code, and 1930 for operations performed with the L operation code.

Timing. T = N [(L_I + 1) + 33.3] ms + disk rotation.*

*35 ms is maximum time for disk rotation.
18.4 ms is average time for disk rotation.
1.7 ms is minimum time for disk rotation.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	B + 9	B + 11 + 2120 (M Op code) or B + 11 + 1920 (L Op code)

Example. Write a disk track (with address) from the data in the area labeled WRTSAD (first position of data is at 1000). The disk-control field is located in the ten positions preceding the label (0990-0999), Figure 50.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	d
3 5	6 7	8 13	14 16	17 23		27	28 34		36	80
0 1 0			M U	%F6			W R T S A D -		1 0	W

Autocoder

Label	Operation	OPERAND
6 15	19 20	21 25 30 35 40 45 50
	W D T	W R T S A D - 1 0

Assembled Instruction: M %F6 990 W

Figure 50. Write Disk Track Sectors with Addresses

Branch If Indicator On

The BRANCH IF INDICATOR ON instruction tests the indicators that might be set ON during a disk-storage operation. When a disk-storage instruction occurs in the program, it turns OFF all disk-storage indicators that were turned ON by a previous disk-storage operation. The execution of a disk-storage instruction can result in a disk-storage indicator being turned ON.

Instruction Format

Mnemonic	*Op Code*	*I-address*	*d-character*
SPS B *A* BIN	B	xxx	x

Function. The d-character specifies the indicator tested. If the indicator is ON, the next instruction is taken from the I-address. If the indicator is OFF, the next sequential instruction is taken. Figure 51 shows symbols that are valid d-characters, and the indicators they test. More than one indicator can be turned ON as the result of a disk-storage operation.

d-Character	Indicator
N	Access Inoperable
V	Disk Error
W	Wrong-Length Record
X	Unequal-Address Compare
Y	Any Disk-Condition
\	Access Busy

Figure 51. d-Characters for BRANCH IF INDICATOR ON Instruction

Because the program continues in sequence, a BRANCH IF INDICATOR ON instruction should immediately follow any disk instruction.

Indicators: Access Inoperable — This indicator turns on if either an invalid (not installed) arm or disk-storage unit is addressed.

An access arm becomes inoperable if the logic safety circuit detects improper operation. A customer engineer can also render an arm inoperable. In either instance, this indicator turns ON, at which time the operation is terminated and the next sequential instruction is started. At the same time, the RAMAC light turns ON.

This indicator also turns on if power is not supplied to the disk-storage unit addressed, or if certain data-safety conditions occur.

The indicator is turned off during the I-phase portion of the next disk-storage operation.

Disk Error. This indicator turns ON if even-bit parity occurs during reading or writing on a disk. Another condition that turns the indicator ON is a data unequal-compare condition during a write-check operation. In this case the operation is completed.

The indicator is turned OFF during the I-phase portion of the next disk-storage operation.

Wrong-Length Record. This indicator turns ON if the following conditions are not satisfied: a group-

mark with a word-mark in core storage is sensed at the same time as an end of sector and an all-zero condition in the sector-control field occurs. It also turns ON during a scan operation if the search argument is longer than, or equal to, a sector length. Detection of a wrong-length record terminates the operation and starts the next sequential instruction.

The indicator is turned OFF during the I-phase portion of the next disk-storage operation.

Unequal-Address Compare. An unequal-address compare condition occurs during the automatic comparison of the sector address in storage with the sector address on the disk. This unequal condition turns the unequal-address compare indicator ON after the disk track is searched and the track-index pulse is sensed twice. This is an automatic check and does not have to be programmed. During multiple-sector operations, the indicator also turns ON after the data transfer begins when the next sector address to be compared does not compare.

The internal circuitry is the same as that used by the COMPARE instruction. In programming, be careful that a normal-compare operation and the address-compare operation do not interfere with the settings of the equal-, low-, and high-compare indicators set by a previous instruction. Detection of an unequal-address compare terminates the operation and starts the next sequential instruction.

The indicator is turned OFF during the I-phase portion of the next disk-storage operation.

Access Busy. This indicator is turned ON if the access assembly is in motion when the program tries to execute a disk-storage instruction. The disk-storage instruction is terminated and the next sequential instruction is started.

The indicator is turned OFF during the I-phase portion of the next disk storage operation.

Any-Disk Condition. This indicator turns ON if any of the other disk-storage indicators are ON. It can be tested by the program, and, if it is OFF, the program can proceed. If this indicator is ON, then the other indicators should be checked to determine where corrective measures should be taken.

The indicator is turned OFF during the I-phase portion of the next disk-storage operation.

Word Marks. Word marks are not affected.

Timing

Without Indexing:

$T = N (L_I + 1)$ ms.

With Indexing:

$T = N (L_I + 2)$ ms.

Note: After each disk-unit read or write operation, the program must test for error indications to prevent processing of unusable data.

Address Registers After Operation

I-Add. Reg.	*A-Add. Reg.*	*B-Add. Reg.*
NSI	BI	dbb

Example. At the completion of a disk-read operation, test the any-disk-unit error-condition indicator. If it is OFF, continue in the main program. If it is ON, branch to the routine labeled DISKER (0690) to determine the type of error condition. This tests all disk-unit indicators and branches to the error routine of the respective indicator that is ON. The routines are labeled: ACINOP (0690), UNADCL (0695) WRLENR (0700), RWPARC (0705), Figure 52.

SPS

LINE	COUNT	LABEL	OPERATION	(A) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	(B) OPERAND ADDRESS	±	CHAR. ADJ.	IND.	d
3 5	6 7	8 13	14 16	17 23			27	28 34			36	39
0 1 0			B	DISKER								Y
0 2 0												
0 3 0												
0 4 0		DISKER	B	ACINOP								N
0 5 0			B	UNADCL								X
0 6 0			B	WRLENR								W
0 7 0			B	RWPARC								V
0 8 0												

Autocoder

Label	Operation	OPERAND
6 15	16 20	21 25 30 35 40 45 50
	BIN	DISKER,Y
DISKER	BIN	ACINOP,N
	BIN	UNADCL,X
	BIN	WRLENR,W
	BIN	RWPARC,V

Assembled Instruction:

480	B	690	Y
690	B	740	N
695	B	790	X
700	B	890	W
705	B	990	V

Figure 52. BRANCH IF INDICATOR ON Testing Routine

IBM 1301 Disk-Storage Timing

The organization of data in disk storage and the method of processing data affect the seek time for a given operation and also affect the total system throughput.

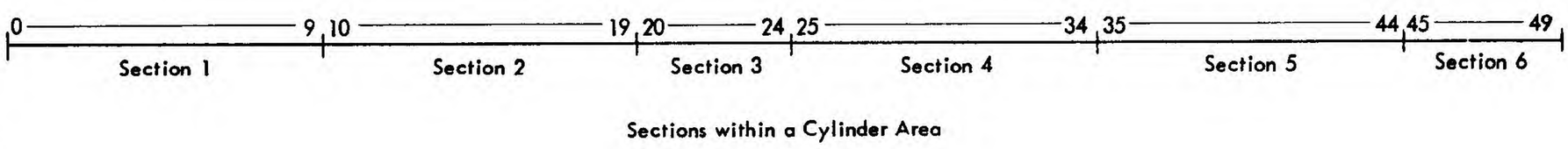
Access Motion Time

The access mechanism requires time to move from one cylinder to another. The time required is related to how far the mechanism moves within certain machine-defined limits. To calculate how much time will be required, consider the 250 cylinders of a module as being organized into five areas of 50 cylinders per area (Figure 53). Also consider each area of cylinders further divided into six sections (Figure 53). Access motion time for any one access can be determined by one of the following statements:

1. To move the access mechanism within a section of any one area requires 50 milliseconds.
2. To move the access mechanism from one section to another section of an area requires 120 milliseconds.
3. To move the access mechanism from one area to another area (crossing an area boundry) requires 180 milliseconds.

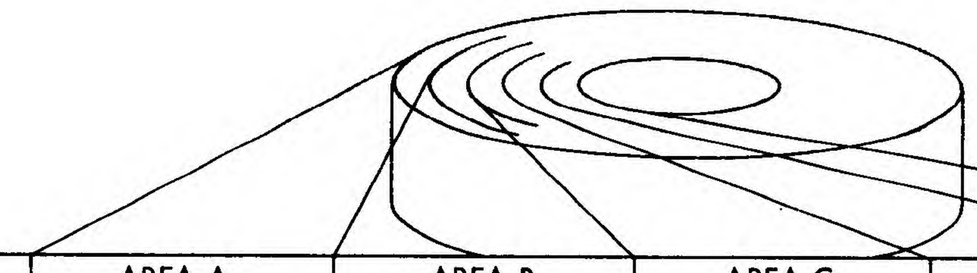
For example, to move the access mechanism from track 000000 to track 039999 requires 120 milliseconds of access motion time. To move the access mechanism from track 039999 to track 040000 requires 180 milliseconds of time.

AREA	CYLINDER
A	0 - 49
B	50 - 99
C	100 - 149
D	150 - 199
E	200 - 249



Sections within a Cylinder Area

Figure 53. Access Motion Areas and Sections



SECTIONS	AREA A Cylinders 0 - 49 Sector Addresses 000000 - 039999	AREA B Cylinders 50 - 99 Sector Addresses 040000 - 079999	AREA C Cylinders 100 - 149 Sector Addresses 080000 - 119999	AREA D Cylinders 150 - 199 Sector Addresses 120000 - 159999	AREA E Cylinders 200 - 249 Sector Addresses 160000 - 199999
1	000000 - 007999	040000 - 047999	080000 - 087999	120000 - 127999	160000 - 167999
2	008000 - 015999	048000 - 055999	088000 - 095999	128000 - 135999	168000 - 175999
3	016000 - 019999	056000 - 059999	096000 - 099999	136000 - 139999	176000 - 179999
4	020000 - 027999	060000 - 067999	100000 - 107999	140000 - 147999	180000 - 187999
5	028000 - 035999	068000 - 075999	108000 - 115999	148000 - 155999	188000 - 195999
6	036000 - 039999	076000 - 079999	116000 - 119999	156000 - 159999	196000 - 199999

NOTE: Numbers shown above are the sector addresses of the lowest - and highest - numbered sector addresses in each section of each area.
Examples: Area A, section 1 contains 800 sector addresses (000000 - 007999)
Area A, section 3 contains 400 sector addresses (016000 - 019999)
Access Motion Time is calculated as follows:

1. Movement between sector addresses in the same section of an area is 50 milliseconds.
2. Movement between sector addresses not in the same section of an area requires:
   120 milliseconds when movement is within the same area
   (Between 000000 and 015000; 020000 and 036000)
   180 milliseconds when movement is between two of the five areas
   (Between 015000 and 055000; 108000 and 168000)

Figure 54. Access Motion Time

Rotational-Delay Time

A disk-storage read or write operation includes a timing factor called *rotational-delay time*. An index point for each circular disk track denotes the beginning and end of a track. After a cylinder of tracks has been accessed and the proper read/write head for a specific track of the cylinder is conditioned, actual reading or writing must wait until the specific data or data area of the track is located. *Rotational-delay time* is the time required for the disk to position the desired record at the selected read/write head after an instruction has been initiated.

Maximum *machine* rotational-delay time is 33.3 milliseconds; average rotational-delay time is 16.7 milliseconds. Data-access time includes the combination of access motion time and rotational-delay time. Figure 54 is a complete chart of access motion time.

Access time from one sector address to another can be determined from Figure 55. The point of intersection of two lines on a coded area of the figure, one drawn horizontally from a FROM sector address and one drawn vertically from a TO sector address, indicates access time in milliseconds.

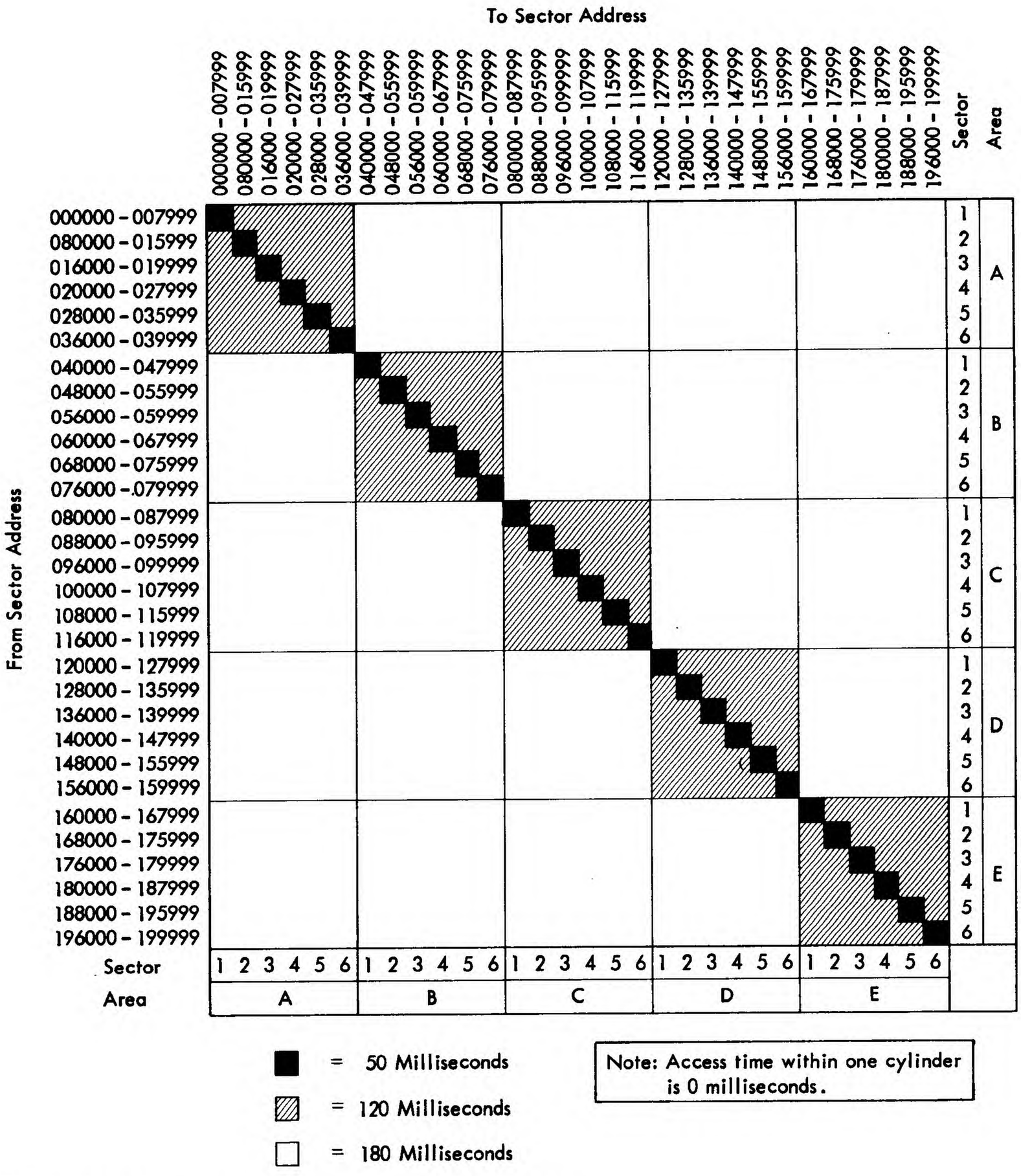


Figure 55. Sector-Address-to-Sector-Address Access Time

Sector Processing Time

The times required to execute a 1-sector and a 3-sector operation are:

	Example 1 1-Sector Operation	Example 2 3-Sector Operation
Seek	160.0 ms	160.0 ms
Average Rotational Delay	16.7 ms	16.7 ms
Read (Includes Module Select Time—1.66 ms)	3.4 ms	6.7 ms
Rotational Delay	30.0 ms	26.7 ms
Write (Includes Module Select Time—1.66 ms)	3.4 ms	6.7 ms
Rotational Delay	30.0 ms	26.7 ms
Write Disk Check (Includes Module Select Time—1.66 ms)	3.4 ms	6.7 ms
	246.9 ms	250.2 ms

If possible, processing should be kept within the available rotational time. If not, the cycle is increased by one 33.3 ms revolution for each extension of available processing time.

Processing time between a write operation and a write-disk-check operation can be used for such processing as updating control totals and/or arranging fields of printing.

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